USER'S GUIDE FOR THE AERMOD METEOROLOGICAL PREPROCESSOR (AERMET)

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USER'S GUIDE FOR THE AERMOD METEOROLOGICAL PREPROCESSOR (AERMET)

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PREFACE

AERMET provides a general purpose meteorological preprocessor for organizing available meteorological data into a format suitable for use by the AERMOD air quality dispersion model. This user's guide provides instructions for setting up and running the AERMET preprocessor. National Weather Service (NWS) hourly surface observations, NWS twice-daily upper air soundings and data from an site-specific meteorological measurement program can be processed in AERMET. There are three stages to processing the data. The first stage extracts meteorological data from archive data files and processes the data through various quality assessment checks. The second stage merges all data available for 24-hour periods (NWS and site-specific data) and stores these data together in a single file. The third stage reads the merged meteorological data and estimates the necessary boundary layer parameters for use by AERMOD. Two files are written for AERMOD: a file of hourly boundary layer parameter estimates and a file of multiple-level observations of wind speed and direction, temperature, and standard deviation of the fluctuating components of the wind. AERMET was designed to allow for future enhancements to process other types of data and to compute boundary layer parameters with different algorithms.

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SECTION 1

INTRODUCTION

The U. S. Environmental Protection Agency (EPA), in conjunction with the American Meteorological Society (AMS), has developed a new air quality dispersion model, the AMS/EPA Regulatory Model (AERMOD). This model requires a preprocessor that organizes and processes meteorological data and estimates the necessary boundary layer parameters for dispersion calculations in AERMOD. The meteorological preprocessor that serves this purpose is AERMET.

1.1 OVERVIEW OF AERMET

AERMET is designed to be run as a three-stage process (Figure 1.1) and operate on three types of data -- National Weather Service (NWS) hourly surface observations, NWS twice-daily upper air soundings, and data collected from an on-site measurement program such as from an instrumented tower. The first stage extracts (retrieves) data and assesses data quality. The second stage combines (merges) the available data for 24-hour periods and writes these data to an intermediate file. The third and final stage reads the merged data file and develops the necessary boundary layer parameters for dispersion calculations by AERMOD.

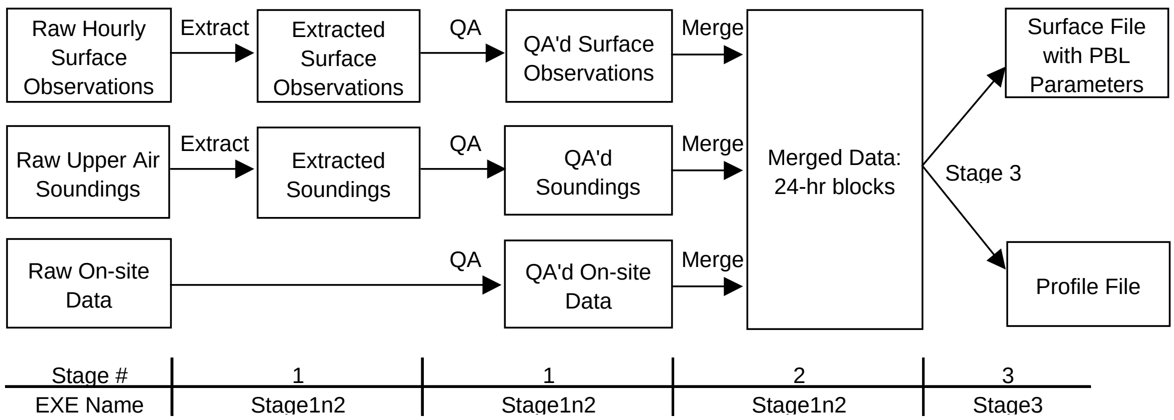

FIGURE 1-1. AERMET PROCESSING.

1.1.1 Stage 1 – Extraction and Quality Assessment

Stage 1 comprises the extraction/retrieval of data and assessment of the quality of the data. Data extraction is generally a one-time activity, while the quality assessment (QA) may be performed several times if the QA identifies problems with the data.

Typically, the NWS upper air and surface data are available from the National Climatic Data Center (NCDC) in a compact format. These formats are designed to minimize the amount of space required to store the data and are not readily interpreted. Therefore, the data that are stored in archive files are first extracted (i.e., retrieved) from the archive file.

AERMET can extract data from several standard NCDC formats. These include the TD-6201 format for upper air sounding data, hourly surface weather observations in the CD-144 format, which is a time-based (i.e., by hour) format, and the TD-3280 format, which is an element-based (i.e., by variable) format for surface data.

AERMET also processes the hourly surface data format available from the EPA Office of Air Quality Planning and Standards (OAQPS) Technology Transfer Network (TTN). This format is a reduced form (fewer variables) of the CD-144 format and is available from the Support Center for Regulatory Air Models (SCRAM) technical area of TTN.

Thirty years of hourly surface observations for all first order NWS stations are now available from the Solar and Meteorological Surface Observation Network (SAMSON) compact discs. While AERMET cannot extract the data directly from the CD, AERMET can process the data the user retrieves from the CD using the extraction software provided with the CDs.

There is no standard format or content for site-specific meteorological data. The data collected site-specific most likely will include observations made at one or more levels on an instrumented tower or from remote sensing instrumentation. Additionally, near-surface measurements such as insolation, net radiation, and temperature difference may be included in the data base. The nonstandardized formats preclude storing these data in a predefined archive format; thus, AERMET does not 'extract' site-specific data. However, AERMET is designed to accept a variety of on-site data formats by having the user specify the structure of the data. The data must be in an ASCII file and able to be read with standard Fortran format statements. Additional restrictions and specification of site-specific data are discussed in more detail in Section 3.

Quality assessment is performed on all the data types. The QA process identifies occurrences of missing data, values that are outside a range of values, and inconsistences between selected variables within an observation period. Default values are defined for the upper and lower bounds and for missing values. The values can be modified through an input file created by the user that controls preprocessor actions. Some variables are checked by default (as noted in the tables in Appendix B) and the user can specify additional variables to be checked.

If AERMET detects anomalous data, a message is written to a file informing the user of the violation. At present there are no provisions for AERMET to automatically replace missing data or correct "suspect" values. The user should review the QA messages and determine if the value(s) require modification or if they are acceptable.

If the data require modification, the output files from Stage 1 can be edited using a text editor (a word of warning: depending on the time period extracted, these files can be very large and easily exceed the size limitations of older text editors). However, any changes should be based on sound meteorological principles and comply with any relevant regulatory guidance. Modifications should only be done on extracted data, and not on the archive file. The archived data should never be altered, but should be maintained as delivered. Whenever changes are made, the modified data should be reprocessed through the QA process a second time. This stepwise procedure may identify new problems that, in turn, need to be addressed. When the user is satisfied that the quality of the extracted data cannot be improved further, the data are ready for the next stage.

1.1.2 Stage 2 – Merging Data

This stage of the processing combines the files from Stage 1 into a single ASCII file. This file is organized so that each block of data contains all of the observations for a 24-hour period. This period begins with hour 1, representing the period from 0001 local standard time (LST) to 0100 LST, and ends with hour 24, representing 2301 LST to 2400 LST. If any input data to this stage of processing are physically missing for the hour (e.g., down-time for instrument maintenance), then the meteorological variables for that hour are represented by the appropriate missing value indicators (as shown in Appendix B or redefined by the user as explained in the following sections).

1.1.3 Stage 3 – Creating Model Input Files

The final stage of processing reads the merged file and, in conjunction with site-specific parameters that characterize the underlying surface, produces two input files for AERMOD. The first file contains boundary layer scaling parameters (such as surface friction velocity, mixing height, and Monin-Obukhov length) and reference-height winds and temperature. The second file contains one or more levels (a profile) of winds, temperature and the standard deviation of the fluctuating components of the wind. Generally, this latter file contains the data from an site-specific measurement program. In the absence of such data, a single level using NWS hourly surface observations may be used for the profile.

Presently, AERMET only creates meteorological input files for AERMOD. However, AERMET's flexibility allows for future expansion to create input files for other dispersion models requiring other algorithms and output formats.

1.1.4 Limitations

The temperature structure of the atmosphere prior to sunrise is required by AERMET to estimate the growth of the convective boundary layer for the day. Currently, AERMET uses the 1200 Greenwich Mean Time (GMT) upper air sounding from the National Weather Service for this purpose. A one hour window of time in the search allows for the possibility of an early or late launch time. This search restricts the applicability of AERMET to those longitudes where the 1200 GMT sounding corresponds to the early morning hours, i.e., the western hemisphere. Future enhancements to AERMET may include a more general search for a "morning" sounding.

1.2 GENERAL FILE STRUCTURE

All the output files through Stage 2 have a similar structure. The files begin with header records and are followed by the data records. The header records are generated from the user-supplied input that controls AERMET's actions. An asterisk appears at the beginning of each header record in an output file. The asterisk has no other purpose than to identify the record as a header. Some of the header records have special (ASCII) characters after the asterisk for AERMET to reprocess these records in subsequent stages. This procedure frees the user from specifying the same information in subsequent runs and provides consistency from stage to stage. For example, the format of the site-specific data is specified only once because the statements that define the format are retained and reprocessed in subsequent AERMET runs. It is important that the user not change any of the header records, otherwise the data could be processed in an undesirable way or cause AERMET to fail with a processing error.

The processed data appear after the header records. The format of these data are defined in Appendix C. The NWS surface and upper air data have been "integerized", i.e., the value is written to the output file as an integer. To retain significant digits for some of the variables, such as temperature and wind speed, the values are multiplied by 10 or 100 before writing the value to the output file. This process is reversed when the data are needed for parameter estimates. However, the site-specific data, with a nonstandard format and content, are written with the same input format specified by the user in the runstream file.

The two output files from Stage 3 contain all the necessary meteorological data required by AERMOD to perform a dispersion analysis. There are no processing header records in these files, although there is a single record at the beginning of the file with the boundary layer parameters that identifies the sites that were used in the processing. The format of these two files are defined in Appendix C.

1.3 BASIC HARDWARE REQUIREMENTS

With the continuing increases in speed and storage capacity of the PC and their ease of use, the PC has become a popular platform for dispersion model applications. As such, AERMET is designed to run on IBM-compatible personal computers with Pentium or higher central processor unit (CPU). A minimum of 64 Mb of random access memory (RAM) is recommended. The source code and two executable programs require approximately 3 Mb of disk space.

For AERMET to process one year of data through Stage 3 (using NWS and site-specific data) requires less than a minute on a 1.0 GHZ Pentium with 64 Mb of RAM. The amount of space required by the data files varies according to the type of data. File sizes range from 0.5 Mb (for one year of upper air soundings) to 6 Mb for a merged data file with all data types and three levels of site-specific data. The output file with the boundary layer parameters requires approximately 1 Mb for one year of data. The file containing the profile data depends on the number of levels in the profile. A single-level profile requires about 500 Kb and a three-level profile requires about 1.5 Mb.

1.4 DOCUMENT OVERVIEW

In Section 2, the basic requirements to run AERMET with National Weather Service data are presented in the form of a basic tutorial. The keyword approach and basic rules for constructing the input control files for each stage of processing are discussed. The AERMET system reports are reviewed. Section 3 presents an advanced tutorial by expanding the first example to include site-specific meteorological data. Section 4 discusses the keywords in more detail, many of which were not used in the tutorial. Section 5 discusses the technical basis for the parameter estimates in the final stage of processing.

Appendices A through D collectively form a reference guide for running AERMET. Appendix A describes the runstream file statements, while Appendix B describes the input variables and their default bounds and missing values codes. Appendix C describes the format and content of the AERMET input and output files. Appendix D describes the various error messages that may be generated by AERMET and suggests why the error message was generated. Appendix E discusses processing data archived on magnetic tape. Appendix F discusses possible future enhancements to the preprocessor.

SECTION 2

GETTING STARTED - A BASIC TUTORIAL

This section is designed to provide the user with a basic understanding of the requirements to run AERMET. In this section, we will:

- explain the pathway and keyword approach, and associated syntax rules, for processing meteorological data through AERMET; and
- present a complete example using NWS hourly weather observations and twice-daily upper air sounding data.

2.1 AERMET COMMAND LANGUAGE

Processing meteorological data with the AERMET preprocessor is divided into three stages as shown in Figure 1-1. Two executable programs perform the three stages of processing. The first program, STAGE1N2.EXE, is used to extract and QA the data (Stage 1) and merge the data into 24-hr periods in a single file (Stage 2). STAGE3.EXE uses the merged data to produce the input files for the user-defined dispersion model. Whenever one of these programs is run, a file containing a sequence of control statements is required to define the actions that AERMET are to perform. This file is referred to as the input runstream file or, simply, runstream.

The statements in a runstream are divided into six functional groups, or pathways, which are:

- JOB - for specifying information pertaining to the entire run;
- UPPERAIR - for extracting and QA'ing NWS upper air sounding data;
- SURFACE - for extracting and QA'ing NWS hourly surface observations;
- ONSITE - for QA'ing user-supplied, on-site meteorological data;
- MERGE - for combining (merging) the meteorological data;

- METPREP - for estimating boundary layer parameters for AERMOD.

The pathway identifier appears on a line by itself and signals the beginning of a contiguous block of statements that apply only to that pathway. There can be from two to five pathways specified in a single AERMET runstream, depending on the input data and stage being processed.

The records within a pathway make use of a keyword and parameter approach for specifying the input to AERMET. The keywords and parameters that make up this file can be thought of as a command language through which the user directs the actions by AERMET. It is the combinations of keywords and parameters that direct AERMET how to process the data. However, there are several rules of syntax that must be observed for AERMET to correctly process the data.

2.1.1 Basic Rules for Structuring a Runstream

While the runstream has been designed to provide the user with flexibility in structuring the file, there are some basic syntax rules that must be followed. These rules standardize the format of the runstream and enable AERMET to process the data such that the desired results are obtained for a particular run. These rules are:

- The pathway identifier appears on a line by itself followed by all the runstream input records for that pathway. In other words, all the records for a particular pathway must be contiguous without any intervening keywords for other pathways.

- Each record in the runstream cannot exceed 80 characters in length. The record can begin in any column, so long as the entire length of the record, including leading blanks, does not exceed 80 characters. For example, records starting with keywords can be indented for readability (as is done throughout this user's guide). Each field on a record must be separated by one or more spaces or a comma and must appear in a particular order (with a few exceptions as noted later in the user's guide).

- Blank records can be included anywhere in the runstream to improve readability.

- If asterisks appear in columns 1 and 2 (**), AERMET ignores the statement. By using the asterisks, the statement acts as a comment, which could be used to identify the purpose of the runstream or to clarify the content of an individual keyword or to ignore an action or option defined by the keyword.

- Alphabetical characters can appear in either upper or lower case letters. AERMET converts these characters to upper case (which is why any information echoed to an output file is all upper case) to insure exact matches on keywords and parameters. Throughout this document, the convention of using upper case letters in the runstreams will be followed. Note: Since file names on UNIX-based systems are case sensitive and since AERMET converts all alphabetic characters to upper case, the names of the files on the computer's storage device would be required to be upper case.

- Some keywords are mandatory, while others are optional. A keyword is mandatory to the extent that there are data to process for the pathway and without the keyword, the eventual product from AERMET (the output files from Stage 3) could not be generated. Optional keywords are used to include or extend data processing actions. Most of the keywords used in the tutorial are mandatory. Some keywords are repeatable, such as the keywords to specify the format of any site-specific data, while others may only appear once. These terms are discussed in more detail in Section 4. Keywords by pathway are provided in Appendix A and are identified as mandatory or optional, repeatable or nonrepeatable.

- The order of keywords within a pathway is not important, except for a few keywords for the ONSITE and METPREP pathways These keywords pertain to the variables and format of the site-specific data and the site-specific surface characteristics on the METPREP pathway.

- File names must conform to the naming conventions appropriate to the computing platform and cannot exceed 40 characters in length.

This section contains discussions of the basic keywords within the context of the tutorial. Section 4 contains a comprehensive discussion of all the keywords for each of the pathways. A summary of all of the keywords for each pathway is presented in Appendix A and forms a complete reference guide regarding the function, syntax, and order (if applicable) of each keyword.

A text editor should be used to create the runstream files as ASCII files. Word processors (e.g., WordPerfect) can be used, but the file must be saved as a "non-document" file, i.e., without special format control characters that are included when the file is saved in its native format. Saving the file in a word processor's native format will introduce characters that cannot be interpreted by AERMET and prevent AERMET from processing any data.

2.2 EXAMPLE 1: NATIONAL WEATHER SERVICE DATA

This first example leads the user through the processes necessary to generate the input runstream files for the AERMOD dispersion model using only NWS data and to run AERMET. This example is divided into four steps and a separate runstream for each of these steps is presented and discussed below. The runstreams will illustrate the basic requirements for each stage. The function and purpose of each record in the runstream will be described in the context of the desired processing.

Before reading the discussion of the keywords and output for this example, we recommend running AERMET to generate the output files - the message files, the summary reports, and the meteorological data output. The four steps and associated runstream file names, which are provided on diskette accompanying this User's Guide, to generate the meteorological data for AERMOD are:

- extract and QA NWS hourly surface observations (Stage 1): EX1-SF.INP
- extract and QA NWS twice-daily upper air soundings (Stage 1): EX1-UA.INP
- combine these two types of data into 24-hour blocks of data (Stage 2): EX1-MRG.INP
- process the combined data to produce the meteorological input for AERMOD (Stage 3): EX1-ST3.INP.

AERMET is a DOS-based program and is run from the DOS prompt. AERMET assumes that information on how to process the data comes from an input file with a "hard-coded" name. The syntax for running the 2 components of AERMET is:

STAGE1N2

or

STAGE3

The name of the file that the executable is looking for is:

STAGE1N2.INP

or

STAGE3.INP

As shown in Figure 1-1, AERMET consists of two executable programs: STAGE1N2.EXE and STAGE3.EXE. STAGE1N2 is used to extract and QA the meteorological data and combine the data (the first three steps in this example), whereas STAGE3 is used to process the combined data and create the meteorological input files for AERMOD (the final step). The following table shows what to type at the DOS prompt for each step in this example. The first two can be run in either order, but steps three and four must follow the first two and run in the order shown.

To:	At the DOS prompt, type:	Meteorological input data file(s)	Output data file(s)
Extract and QA NWS hourly surface data	COPY EX1-SF.INP STAGE1N2.INP STAGE1N2	S1473588.144	SFEXOUT.DSK SFQAOUT.DSK
Extract and QA NWS upper air data	COPY EX1-UA.INP STAGE1N2.INP STAGE1N2	14735-88.UA	UAEXOUT.DSK UAQAOUT.DSK
Merge data	COPY EX1-MRG.INP STAGE1N2.INP STAGE1N2	SFQAOUT.DSK UAQAOUT.DSK	MERGE.DSK
Create meteorological files for AERMOD	COPY EX1-ST3.INP STAGE3.INP STAGE3	MERGE.DSK	AERMET.SFC AERMET.PFL

As AERMET runs, the progress is displayed on the screen. The display is described below, after the discussion of the keywords. In addition to the output data files, each run will produce a message file (with a .MSG extension) and report file (.RPT) file. Note: the file names and extensions are all user-defined; i.e., there are no default names or extensions.

A word of caution for this example and for all AERMET runs: all output files are opened with the Fortran file OPEN specifier of STATUS = 'UNKNOWN'. With this specifier, if the file already exists, the contents will be overwritten without any opportunity to save it.

The minimum meteorological input data requirements using only NWS data to produce the two meteorological files for input to AERMOD are:

Hourly Surface Observations:

- wind speed and direction;
- ambient temperature;
- opaque sky cover; in the absence of opaque sky cover, total sky cover;
- station pressure is recommended, but not required, since it is used only to calculate the density of dry air; AERMET will use a default value of 1013.25 millibars (sea level pressure) in the absence of station pressure.

Upper Air Soundings:

- morning sounding (the 1200 GMT sounding for applications in the United States).

2.2.1 Stage 1 - Processing Hourly Surface Observations

Figure 2-1 shows the steps for processing the NWS hourly surface observations in Stage 1. The entire flow diagram shown in Figure 1-1 is shown here, but the steps that are not required to process the surface data do not contain any text.

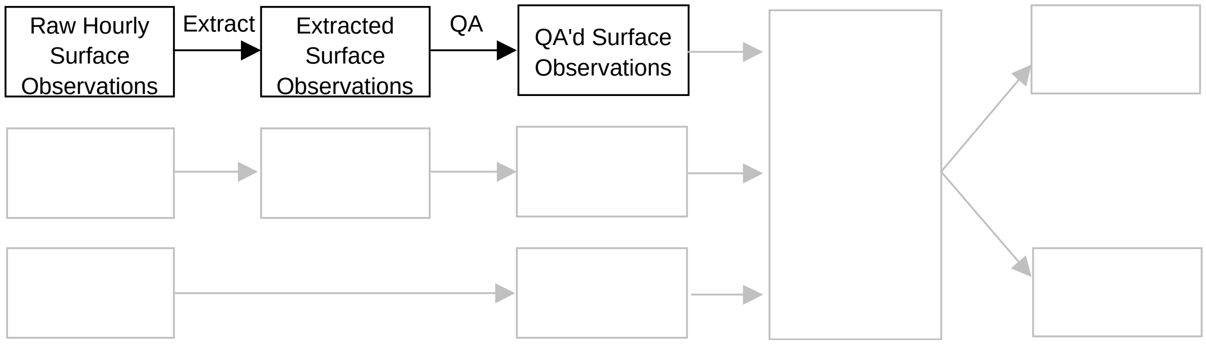

FIGURE 2-1. STAGE 1 PROCESSING FOR HOURLY SURFACE OBSERVATIONS.

The first step in this example is to extract and QA the hourly surface observations from the data archive file. Figure 2-2 shows the runstream for this step, which is provided in the file EX1-SF.INP. Blank records have been inserted between records and the keywords indented to enhance legibility. This same style can be used when creating runstreams for AERMET on a PC. Throughout this tutorial, the pathways, keywords and parameters required by AERMET are on the left and in bold in the figures showing the runstreams. The text to the right provides a short comment on the pathway or keyword and must <u>not</u> appear in the runstreams used to run AERMET (the comments are omitted in the files provided for this tutorial).

```
JOB                                         Start of the JOB pathway

  MESSAGES   SURFACE.MSG                    File for all messages

  REPORT     SURFACE.RPT                    File for the run summary

SURFACE                                           Start of the SURFACE pathway

  DATA             S1473588.144  CD144  1          Archive data file,
                                                   format, blocking factor

  EXTRACT    SFEXOUT.DSK                    File to which the extracted data are
                                            written

  XDATES     88/3/1  TO  88/Ø3/1Ø                 Dates to extract from the
                                                  archive file

  LOCATION   14735  42.75N  73.8W  Ø              Station identifier, latitude,
                                                  longitude, and conversion to
                                                  local time

  QAOUT            SFQAOUT.DSK                    File for the output from QA
```

FIGURE 2-2. EXAMPLE RUNSTREAM TO EXTRACT AND QA NWS SURFACE DATA.

2.2.1.1 <u>JOB pathway</u>

This pathway is common to all AERMET runs and may appear anywhere in the runstream file, but it usually appears first. The basic keywords associated with the JOB pathway are:

MESSAGES - specifies the file name where all the errors, warning and informational messages generated by AERMET are written; a mandatory keyword.

REPORT - specifies the file name where the summary of the run is written; an optional, but highly recommended, keyword. If this keyword is omitted, then the report streams to the default output device, usually the screen, and can be captured to a file using DOS redirection on a PC (discussed later in this section).

In this example, the messages are written to SURFACE.MSG and the report is written to SURFACE.RPT. The files are written in the directory in which AERMET is started. The files are ASCII files that can be viewed with any common text editor or viewing program. Both files contain information that can be used to determine if a particular run was successful or failed, and if the run failed, give possible reason(s).

There are several hundred different places in AERMET that could generate a message - from an error (fatal to processing) to a warning (could cause problems) to an informational message. Messages are written at the time the runstream is processed as well as when data are processed. Appendix E contains a list of these messages with a brief explanation of each. Depending on the pathways and keywords defined in a particular run, this file could be very long, particularly when the data are QA'd, so it is advisable to check the size or view it prior to printing it.

One other keyword is associated with the JOB pathway:

CHK_SYNTAX - checks the syntax of the runstream file for errors, without processing any data; use this keyword to check a newly created runstream before processing any data to locate possible syntax errors.

A detailed discussion of all the keywords for the JOB pathway is provided in Section 4, with a synopsis of each keyword in Appendix A.

2.2.1.2 SURFACE pathway

The SURFACE statement indicates that a block of keyword statements for the SURFACE pathway are to follow. The basic keywords required to extract and assess the quality of NWS surface data are:

DATA - specifies the input file name of the archived data and the file format for the extraction process;

EXTRACT - specifies the output file name of extracted data; this keyword also specifies the input file name for the data QA;

XDATES - specifies the period of time to be extracted from the archived data file;

LOCATION - specifies the station identifier, latitude and longitude, and the factor to convert the time of each data record to local standard time;

QAOUT - specifies the output file name from the QA process; this keyword is also used to specify the input file name to Stage 2 - see Section 2.2.3.

The order of these keywords within the SURFACE pathway is not important. The presence of both the DATA and EXTRACT keywords (without error) directs AERMET to extract hourly observations from a file of archived data. The presence of both the EXTRACT and QAOUT keyword statements directs AERMET to assess the quality of the data. Therefore, in this example, the surface data will be both extracted and QA'd.

DATA and EXTRACT

The first parameter associated with the DATA keyword identifies the name of the archive data file, S1473588.144 in this example. On a PC, the file name must conform to the standard operating system naming convention and is limited by AERMET to 40 characters. The second parameter, CD144 in this example, identifies the archive format of the file.
The format parameter indicates that the archive data are in NCDC's CD-144 format, which consists of all the weather observations for one hour on a single, 80-column record.

In addition to the CD144 format, AERMET can process two other formats on the PC: SCRAM and SAMSON. These formats are discussed in detail in Section 4.3. A fourth format, TD-3280, is for data that are stored on magnetic tape and is discussed in Appendix E.

The parameter after the format is the data blocking factor and indicates the number of observations (logical records) per physical record in the file. In this example, the blocking factor is 1. The default value for this parameter is 1, and the value could have been omitted in this example. For data on a diskette, there is normally only one observation per physical record. However, CD-144 archive data have been available from NCDC on magnetic tape may and usually consist of more than one logical record per physical record as a space-saving measure. Hence, the field for the blocking factor.

The EXTRACT keyword specifies the name of the file to which the extracted data are to be written. It is an ASCII file. In this example, the data are written to SFEXOUT.DSK. The hourly surface data are written to the output file as integers, with some variables multiplied by 10 or 100 to retain significant digits. Information on the specific structure for NWS hourly surface observations in the extracted data file is provided in Appendix C.

XDATES

XDATES identifies the inclusive dates, in the form YY/MM/DD, of the data to be retrieved, where YY is the year, MM is the month, and DD is the day, all specified as integers. The word "TO" is optional and is ignored during processing if it is present. The "/" between each part of the date is required. There can be no blanks in the date field, otherwise AERMET will not correctly interpret this record and will terminate with an error. In this example, NWS hourly surface observations for the period March 1, 1988 through March 10, 1988, inclusive, are extracted from the archive file. Notice that the month and day can be specified with or without leading zeros.

LOCATION

The LOCATION keyword is required and specifies station information on which data are to be extracted from the archive file. The parameters associated with this keyword are the station identifier, latitude, longitude, and a time conversion factor. In this example, the station identifier is 14735 and is a Weather Bureau Army Navy (WBAN) number (discussed in Section 4) for Albany, New York. This station identifier is carried through all the stages of processing and appears on the first record of the boundary layer parameter output file from Stage 3. The NWS station latitude and longitude are specified in decimal degrees. These coordinates can be specified in either order, but the directional specifiers (N and W in this case) are required. AERMET does not recognize "+" and "-" to distinguish between north or south and east or west; therefore, latitude and longitude should be specified as positive numbers. The LOCATION keyword also defines the number of hours required to convert the time of each data record to local standard time (LST). For stations west of Greenwich, this value is specified as a positive number. Since most formats reporting hourly surface observations use local standard time, the conversion is usually 0, which is the default value. Therefore, if this adjustment is zero, this parameter can be omitted. If data are reported in GMT, then the number of time zones west (positive number) or east (negative number) of Greenwich is specified.

QAOUT

The QAOUT keyword identifies the file where the data that have undergone the QA process are written. In this example, the output is written to SFQAOUT.DSK.

Several variables on the SURFACE pathway are checked (audited) by default. These are the total and opaque sky cover, station pressure, dry bulb temperature, and wind speed and direction. During the quality assessment process, audited variables are checked as being missing or outside a range of acceptable values. The default values for the SURFACE pathway are defined in Appendix B, Table B-2. A violation of the range or a missing value is reported in the message file, SURFACE.MSG. The variable name, value, upper or lower bound (depending on the violation) or missing value indicator, and date/time are reported in this file (the structure of the message is explained in Appendix D). The user should review the message file to determine if the violations are true errors (e.g., a temperature of 100 °C) and need correction or if they can be ignored (e.g., a temperature that is 0.1 °C higher than an upper bound of 35 °C). The total number of violations and missing values are summarized by variable in the REPORT file, SURFACE.RPT. In the message and summary files, the value and bound or missing indicator is multiplied by the same factor that was used to "integerize" the data (see the discussion for the EXTRACT keyword above). This "integerization" should be kept in mind when reviewing the results of the QA.

The AERMET preprocessor does not make changes to the data during the QA process. If the quality assessment identifies any problems, then either the extracted data file or the QA output file can be edited to manually correct the data in accordance with sound meteorological principles and within any relevant regulatory guidelines. If the modifications are extensive, it is recommended that the data be reprocessed through the QA to identify any problems that may be introduced as a result of the modifications.

The output file from the QA process is identical to the input file, except for the addition of a header record. The preprocessor reads the hourly data and writes the same data to the output file. One may question the need for a separate QA output file since the data are a copy of the EXTRACT output file. The answer is that this method will allow for future accommodation of automatic replacement procedures for missing values, if such procedures are established. By having the two files (identified with the EXTRACT and QAOUT keywords), the AERMET system has a logical design for assessing the data, reporting suspect or missing values, and storing the new or modified values.

There are several additional keywords for the SURFACE pathway that are optional:

AUDIT - adds variables to the list of default variables to be tracked during QA; use the names in the Table B-2 to identify the additional variables;

RANGE - allows the user to modify the default lower and upper QA bounds, the inclusion/exclusion of the endpoints, and the missing value indicator for the variable specified;

NO_MISSING - suppresses the message that data are missing for variables being tracked (audited) during the QA process; this keyword is useful in reducing the size of the message file if an audited variable is missing most of the time.

A detailed discussion of each of the valid keywords for the SURFACE pathway is provided in Section 4, with a synopsis of each in Appendix A.

2.2.1.3 Running STAGE 1 and reviewing the output

Once a runstream has been created, the next step is to run the appropriate program for the stage of processing, which was described at the beginning of this section. To extract data from an archive file and QA the data, the executable STAGE1N2.EXE is used (as shown in Figure 1-1). To run STAGE1N2 with EX1-SF.INP to extract and QA the NWS hourly surface observations, the following commands are typed at a DOS prompt on the PC:

```
COPY EX1-SF.INP STAGE1N2.INP
STAGE1N2
```

Note that it is not necessary to include the .EXE extension to invoke the executable program.

As AERMET runs, the progress is displayed on the screen. AERMET first displays which executable is running and the version date. Next, the message "Processing the Setup Information" is displayed as the runstream records are processed. If there is an error in the runstream, AERMET will display the message

```
*********************************************************
             ***       AERMET Setup Finished UN-successfully
***

*********************************************************
```

If the setup processing is successful, the data processing begins. The year, month, and day are displayed as each day is processed. Once all the data are processed, AERMET displays a message that the processing is complete and the summary report is being written. If the data were successfully processed, the following message is displayed:

```
*********************************************************
             ***   AERMET Data Processing Finished Successfully
***

*********************************************************
```

For an unsuccessful run (e.g., a period of time not included in the archive file is specified with the XDATES keyword such that no data are extracted), the following is displayed:

```
*********************************************************
             ***  AERMET Data Processing Finished
UN-successfully ***

*********************************************************
```

In both of these latter cases, the final message displayed on the screen informs the user where to locate the summary report.

As was noted above, the REPORT keyword on the JOB pathway is optional. If the keyword is used, then the summary information will be written to the file associated with the REPORT keyword. If there is no REPORT keyword, then the summary information will be written to the standard output device, which is normally the video monitor on a PC. Since the summary fills more than one screen, the report can be sent to a destination other than the screen by redirecting the report to a file as follows:

```
STAGE1N2  >  STAGE1.LOG
```

The ">" directs AERMET to send output that would be written to the screen to the file STAGE1.LOG. However, if this method is used, then <u>all</u> information displayed on the screen is captured in the file, including the lines showing the progress of the processing.

Figure 2-3 shows the message file that results from running EX1-SF.INP. Most of the messages are easily interpreted and relate to the data QA. The structure of these messages is explained in Appendix D. Briefly, the first field is either a counter, blank or a date; the second field is the pathway; the third field is a three-character code used to tabulate the messages for the REPORT file; the fourth field is the subroutine that generated the message; and the fifth field is the message.

```
         JOB        I19  SETUP: FOUND "END OF FILE" ON UNIT  5 AFTER RECORD #  10
         JOB        I25   TEST: SUMMARY: NO DATA EXTRACTION FOR UPPERAIR
         JOB        I25   TEST: SUMMARY: NO DATA QA FOR UPPERAIR
         JOB        I27   TEST: SUMMARY: NO DATA QA FOR ONSITE
         SURFACE    I40  SFEXT: *** SURFACE OBSERVATION EXTRACTION ***
         SURFACE    I49 GETSFC: END-OF-DATA WINDOW ENCOUNTERED
         SURFACE    I49  SFEXT:  240 SURFACE RECORDS EXTRACTED
  880302 SURFACE    CLM SFQASM: CALM WINDS FOR HR 02
  880302 SURFACE    CLM SFQASM: CALM WINDS FOR HR 03
  880302 SURFACE    CLM SFQASM: CALM WINDS FOR HR 04
  880302 SURFACE    CLM SFQASM: CALM WINDS FOR HR 05
  880302 SURFACE    CLM SFQASM: CALM WINDS FOR HR 06
  880302 SURFACE    CLM SFQASM: CALM WINDS FOR HR 07
  880303 SURFACE    CLM SFQASM: CALM WINDS FOR HR 19
  880303 SURFACE    CLM SFQASM: CALM WINDS FOR HR 21
  880306 SURFACE    CLM SFQASM: CALM WINDS FOR HR 00
  880306 SURFACE    CLM SFQASM: CALM WINDS FOR HR 01
  880306 SURFACE    CLM SFQASM: CALM WINDS FOR HR 02
  880306 SURFACE    CLM SFQASM: CALM WINDS FOR HR 03
  880306 SURFACE    CLM SFQASM: CALM WINDS FOR HR 04
  880306 SURFACE    CLM SFQASM: CALM WINDS FOR HR 05
  880306 SURFACE    CLM SFQASM: CALM WINDS FOR HR 06
  880306 SURFACE    CLM SFQASM: CALM WINDS FOR HR 07
  880308 SURFACE    CLM SFQASM: CALM WINDS FOR HR 21
  880308 SURFACE    CLM SFQASM: CALM WINDS FOR HR 22
  880309 SURFACE    CLM SFQASM: CALM WINDS FOR HR 00
  880309 SURFACE    CLM SFQASM: CALM WINDS FOR HR 01
         SURFACE    I49 SFQASM: END OF FILE AFTER HOURLY OBS #   240
```

FIGURE 2-3. MESSAGE FILE THAT RESULTS FROM RUNNING EX1-SF.INP.

The first four messages are informational messages, as denoted by the 'I' in the first position in the third field, and pertain to the runstream setup processing. The first message indicates that 10 records (including blank and comment lines) were processed before encountering an end of file on the input runstream. This is usually the first record in the message file. The next three records indicate actions that will not be performed and relate to the UPPERAIR and ONSITE pathways. The remaining messages pertain to the processing of the NWS hourly surface observations. Records 5-7 indicate that data were extracted for the SURFACE pathway, the end of the extraction window (as defined by the XDATES keyword) was encountered in the input data, and that 240 records were extracted. This value can be used to determine if the correct number of records were processed. In this example, since the XDATES keyword specified the 10-day period March 1-10, one would expect that 240 records (10 days x 24 hours/day) should be extracted. Since 240 records were extracted, we can be reasonably certain that AERMET processed the data correctly. The QA will assist in making the final determination. These informational messages are followed by QA messages. In this example, all the QA messages pertain to calm winds, as denoted by the 'CLM' in the third field. The number at the left of the message indicates the year, month, and day the calm wind was encountered and the hour is contained in the body of the message. The final record in this file is another informational record indicating that the end of file on the QA input file (associated with the EXTRACT keyword) was encountered after record number 240, the same number of records that were extracted. These messages do not indicate anything unusual during the processing of the hourly surface observations.

The summary report file is composed of the following general features:

- a banner identifying AERMET and the data and time the data were processed; this banner appears at the top of each new AERMET report page (ASCII character 22 is inserted to force a page break);

- a message enclosed by asterisks indicating the success or failure of the setup or data processing;

- summary of information and processing in words and tables.

Figures 2-4a through 2-4c show the report file that was generated. This file summarizes the input information and tabulates the messages and QA results. In Figure 2-4a, the AERMET banner is followed by the message that the setup processing finished successfully. The user should look for this message to confirm that there were no problems in the setup processing. This message is followed by the runstream input summary and contains information by pathway:

1. JOB - the file names for the message and summary files;

2. UPPERAIR - AERMET determined that there were no upper air data to process in this run;

3. SURFACE - AERMET determined that NWS hourly surface observations are to be processed and summarizes the information as follows:

    a) the station information (identifier, latitude, longitude and time conversion factor);
    b) a message on what processing AERMET performed on the data - extract and QA in this example;
    c) the input and output file names and if they were successfully opened;
    d) the extract dates;

4. ONSITE - AERMET determined that there were no site-specific data to process in this run

Compare the information in this figure to the runstream in Figure 2-2 and the message file in Figure 2-3 and you will see that this figure reflects the input runstream and records 2 through 4 of the message file (the summary of the actions that were not performed).

Figure 2-4b shows the tabulation of the messages that appear in Figure 2-3. This table starts on a new page, therefore, the AERMET banner appears at the top. The banner is followed by the message that the data processing finished successfully. This is the identical message that is displayed on the screen when AERMET completes a successful run. Next is a record indicating general processing activity (EXTRACT AND/OR QA THE METEOROLOGICAL DATA). This record is followed by the table. Below the table, any error and warning messages that appeared in the message file are redisplayed here. In this example, there were no error or warning messages.

AERMET uses the third field in a message to construct the table. Only messages that utilize the 'E', 'W', 'I', and 'Q' in the first position of the third field are tabulated. Messages with special message codes, such as 'CLM', are excluded from this tabulation. The second and third positions of the third field relate to the pathway being processed, as explained in Appendix D. While the message file contains the individual messages, this table displays the distribution of these messages.

Figure 2-4c shows the summary of the QA, which begins on a new page. This table summarizes all QA messages generated by AERMET. The table includes the variable name (as defined in Table B-2) on the far left, the total number of observations of that variable, the number missing, the number of lower and upper bound violations, and the percent accepted. On the right side of the table, the values that the data were tested against are shown. Recall that all hourly observations are converted to integer format, with some values (such as wind speed and temperature) multiplied by 10 to retain significant digits. These same multipliers are applied to the values on the right side of the QA summary table. Table B-2 shows which variables have been multiplied by 10 (1000 in the case of precipitation). The user is reminded of this fact below the table.

In addition to the bounds violations and missing data, AERMET also checks for other anomalous data: calm winds, zero wind speed and nonzero wind direction, dew point temperature greater than ambient air temperature. The processing summary table (Figure 2-3b) did not include these QA results, but are summarized below the QA summary table. Compare this summary to Figure 2-3. There are 20 messages in Figure 2-3 with the 'CLM' code, which is the number reported in this summary.

This QA summary provides a quick means of assessing the validity of the data. AERMET only performs simple data comparisons and reports its findings. It is up to the user to determine if the reported violations are indicative of an error in the data or if the limits are too restrictive. If the reported violation is due to the latter condition, the RANGE keyword can be used to define new limits and the QA can be run again (without extracting the data again, as described at the end of Section 3). If the reported violation is an error in the data, then the user will have to judge on how to proceed - correcting the data or changing the data to indicate that it is missing.

```
     AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                              Version  98314

                   Data Processed on 11-NOV-98 at 08:55:41

          ********************************************************
          ***        AERMET Setup Finished Successfully        ***
          ********************************************************

 1.  Job File Names

     Listing of Messages: SURFACE.MSG
     Summary (this file): SURFACE.RPT


 2.  Upper Air Data

     AERMET Has Determined That Processing For This Pathway Includes:
          NONE, NO DATA TO BE PROCESSED ON THIS PATH



 3.  NWS Surface Data

      Site ID    Latitude(deg.)   Longitude(deg.)   Conversion to LST
        14735       42.75N             73.8W                 0

     AERMET Has Determined That Processing For This Pathway Includes:
          EXTRACT AND QUALITY ASSESSMENT

          Extract Input -    OPEN: S1473588.144
          Extract Output-    OPEN: SFEXOUT.DSK
          QA Output     -    OPEN: SFQAOUT.DSK

          The Extract Dates Are:    Starting:  1-MAR-88
                                      Ending: 10-MAR-88


 4.  On-site Data

     AERMET Has Determined That Processing For This Pathway Includes:
          NONE, NO DATA TO BE PROCESSED ON THIS PATH
```

FIGURE 2-4a. FIRST PART OF THE REPORT FILE FROM PROCESSING NWS HOURLY SURFACE OBSERVATIONS.

```
AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                         Version  98314

               Data Processed on 11-NOV-98 at 08:55:44

       ********************************************************
       ***   AERMET Data Processing Finished Successfully   ***
       ********************************************************

              EXTRACT AND/OR QA THE METEOROLOGICAL DATA

               **** AERMET MESSAGE SUMMARY TABLE ****

       0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
      ----------------------------------------------------------------------

 JOB
   E     0       0       0       0       0       0       0       0       0
   W     0       0       0       0       0       0       0       0       0
   I     0       1       3       0       0       0       0       0       4

 SURFACE
   E     0       0       0       0       0       0       0       0       0
   W     0       0       0       0       0       0       0       0       0
   I     0       0       0       0       4       0       0       0       4
   Q     0       0       0       0       0       0       0       0       0
      ----------------------------------------------------------------------
         0       1       3       0       4       0       0       0       8

     ****    ERROR MESSAGES  ****

           ---  NONE  ---


     ****   WARNING MESSAGES ****

           ---  NONE  ---
```

FIGURE 2-4b. SECOND PART OF THE REPORT FILE FROM PROCESSING NWS HOURLY SURFACE OBSERVATIONS.

```
AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                        Version  98314

              Data Processed on 11-NOV-98 at 08:55:44

       ********************************************************
       ***   AERMET Data Processing Finished Successfully   ***
       ********************************************************


                **** SUMMARY OF THE QA AUDIT ****


SURFACE DATA          |------VIOLATION SUMMARY------|   |-----TEST VALUES-----|
              TOTAL     #     LOWER  UPPER     %       MISSING   LOWER   UPPER
              # OBS  MISSING  BOUND  BOUND  ACCEPTED     FLAG    BOUND   BOUND
      PRES     240       0      0      0    100.00     99999.0, 9000.0,10999.0
      TS       240       0      0      0    100.00        99.0,    0.0,   10.0
        KC     240       0      0      0    100.00        99.0,    0.0,   10.0
      TMPD     240       0      0      0    100.00       999.0, -300.0,  350.0
      WDIR     240       0      0      0    100.00        99.0,    0.0,   36.0
      WSPD     240       0      0      0    100.00     -9999.0,    0.0,  500.0

NOTE: Test values were also multiplied by the same factors applied to the data
      (see Appendix B of the AERMET User's Guide)


       In addition, for the   240 hourly obs, AERMET reports that there are:

            20 CALM WIND CONDITIONS (WS=0, WD=0)
             0 ZERO WIND SPEEDS WITH NONZERO WIND DIRECTIONS
             0 DEW-POINT GREATER THAN DRY BULB TEMPERATURES

       The date & time of these occurrences can be found in
       the message file SURFACE.MSG
       with the qualifiers CLM, WDS, TDT (resp.)


    THIS CONCLUDES THE AUDIT TRAIL
```

FIGURE 2-4c. THIRD PART OF THE REPORT FILE FROM PROCESSING NWS HOURLY SURFACE OBSERVATIONS.

2.2.2 Stage 1 - Processing Twice-Daily Soundings

The steps required to process the upper air soundings through stage 1 are shown in Figure 2-5.

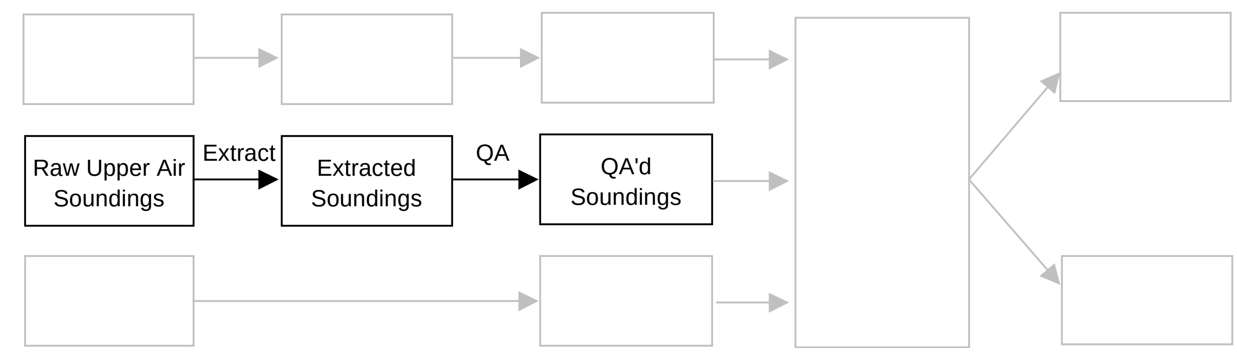

FIGURE 2-5. STAGE 1 PROCESSING OF THE UPPER AIR SOUNDINGS.

The next step in this tutorial is the extraction and QA of the twice-daily upper air soundings. Figure 2-6 shows the runstream for this step and is provided in the file EX1-UA.INP. The text to the right on each record provides a short comment on the pathway or keyword and must not appear in the runstream.

```
JOB                                      Start of the JOB pathway

  REPORT     UPPERAIR.RPT                File for all messages

  MESSAGES   UPPERAIR.MSG                File for the run summary

UPPERAIR                                 Start of the UPPERAIR pathway

  DATA             14735-88.UA  6201FB  1          Archive data file name,
                                                   format, blocking factor

  EXTRACT    UAEXOUT.DSK                 File  to  which  the  extracted data are
                                         written

  XDATES     88/3/1  TO  88/3/10         Dates to extract from the archive file

  LOCATION   00014735  73.8W  42.75N  5       Station identifier and location
                                              information

  QAOUT            UAQAOUT.DSK                File for the output from QA

  AUDIT            UATT UAWS UALR                  Upper air variables to QA
```

FIGURE 2-6. EXAMPLE RUNSTREAM TO EXTRACT AND QA NWS UPPER AIR SOUNDING DATA.

The discussion for the JOB pathway associated with the extraction and QA of the hourly surface observations in Section 2.2.1 applies here as well. The messages and summary report for this run are written to UPPERAIR.MSG and UPPERAIR.RPT, respectively.

2.2.2.1 UPPERAIR pathway

The UPPERAIR statement indicates that a block of keywords for the UPPERAIR pathway are to follow. The extraction and quality assessment of NWS upper air sounding data is very similar to that of NWS surface data and uses the same basic keywords. The keywords used in this example are:

DATA - specifies the input file name of the archived data, the file format for the extraction process, and the data blocking factor;

EXTRACT - specifies the output file name of extracted data; this keyword also is used for the input file name for the data to QA;

XDATES - specifies the period of time to be retrieved from the archived data file;

LOCATION - specifies the station identifier, latitude and longitude and the factor to convert the time of each data record to local standard time;

QAOUT - specifies the output file name from the QA process; this keyword is also used to specify the input file name to Stage 2 - see Section 2.2.3;

AUDIT - this keyword is optional; since none of the UPPERAIR variables are automatically checked, then variables are QA'd on the UPPERAIR pathway only if this keyword is used to include them in the QA .

The order of these keywords within the UPPERAIR pathway is not important. The presence of both the DATA and EXTRACT keywords directs AERMET to extract soundings from a file of archived data. The presence of both the EXTRACT and QAOUT keyword statements directs AERMET to assess the quality of the sounding data. Therefore, in this example, the upper air data will both be extracted and QA'd.

DATA and EXTRACT

The first parameter associated with the DATA keyword identifies the name of the archived data file, 14735-88.UA in this example. As with any file name in a runstream, the name could include a drive and directory path so long as the length of the name does not exceed the (AERMET-imposed) 40-character limit. The second parameter, 6201FB, identifies the format of the archive data set. This parameter indicates that the data are in NCDC's TD-6201 format (the 6201 portion) and that the data are fixed-length blocks (the FB part). Sounding data in this format consist of 2876-character records with 79 levels of data per record. If there are less than 79 levels in a sounding, the record is filled out with missing data indicators. The parameter after the format is the data blocking factor and indicates the number of soundings (logical records) per physical record in the file. In this example, the blocking factor is 1. The default value for this parameter is 1 and the value could have been omitted in this example. For data on a diskette, there is a maximum of one sounding per physical record. However, archive files on magnetic tape may contain more than one logical record per physical record variable-length blocks as a space-saving measure. The discussion in Section 4.4 provides additional discussion on fixed-length and variable-length blocks and blocking factors for the UPPERAIR pathway. Currently, AERMET is designed to retrieve data only from the TD-6201 format.

The EXTRACT keyword specifies the name of the file to which the extracted data are to be written. It is an ASCII file. In this example, the data are written to UAEXOUT.DSK. Information on the specific structure for NWS upper air soundings in the extracted data file is provided in Appendix C. The sounding data are written to the output file as integers, with some variables multiplied by 10 or 100 to retain significant digits.

XDATES

XDATES identifies the inclusive dates, in the form YY/MM/DD, of the data to be retrieved, where YY is the year, MM is the month, and DD is the day, all specified as integers. The word "TO" is optional and is ignored during the processing of this keyword if it is present. The "/" between each part of the date is required and there can be no blanks in the date field, otherwise AERMET will terminate with an error. In this example, data for the period March 1, 1988 through March 10, 1988, inclusive, are extracted from the archive file.

LOCATION

The LOCATION keyword is required and specifies station information on which data are to be extracted from the archive file. The parameters associated with keyword are the station identifier, latitude, longitude, and the conversion of the sounding time to local standard time. In this example, the station identifier is 00014735 and corresponds to Albany, New York. Unlike the SURFACE pathway, the UPPERAIR identifier requires leading zeros because this field contains leading zeroes in the archive file and the field is read as a character variable rather than an integer. Hence, for AERMET to match the station identifier in the archive file with the identifier in the runstream, the leading zeroes are required. This station identifier is carried through all the stages of processing and appears on the first record of the boundary layer parameter output file from Stage 3.

The NWS station latitude and longitude are specified in decimal degrees. These coordinates can be specified in either order, but the directional specifiers (N and W in this case) are required. AERMET does not recognize "+" and "-" to distinguish between north or south and east or west. Therefore, latitude and longitude should be specified as positive numbers. The LOCATION keyword also defines the number of hours required to convert the time of each data record to local standard time. For stations west of Greenwich, a positive value for this factor must be specified. The times in the archive file are reported in GMT and this conversion factor is subtracted from GMT to obtain local standard time. The reason for performing this operation is to insure that all data for the current day are properly specified for the Stage 2 merging process. In this example, to convert the time to Eastern standard time (the time zone for 73.8 west longitude), AERMET subtracts the last parameter for this keyword (5) from GMT to get LST. For sounding dates in this archive file, this adjustment yields 1900 LST of the previous day for the 0000 GMT sounding and 0700 LST for the 1200 GMT sounding in the extracted file.

QAOUT and AUDIT

The QAOUT keyword identifies the file where the data that have passed through the quality assessment are written. In this example, the output is written to UAQAOUT.DSK.

By default, no upper air variables are automatically checked (audited) in the QA process. The AUDIT keyword must be used to QA the data for missing data and range violations. The variable names, as shown in Table B-1, are specified on this statement. In this example, the temperature (UATT), wind speed (UAWS) and lapse rate (UALR) are checked. While the temperature and wind speed are in the file of extracted data, the lapse rate is computed during the QA. The lapse rate can alert the user to unusual, but possibly valid, variations in the temperature structure of the atmosphere, such as strong elevated inversions. However, it is not retained for further use (i.e., the lapse rate is not saved in the output file).

During the quality assessment process, audited variables are checked as being missing or outside a range of acceptable values. The default values for the UPPERAIR pathway are defined in Table B-1. A violation of the range or a missing value is reported in the message file, UPPERAIR.MSG. The variable name, value, upper or lower bound (depending on the violation) or missing value indicator, and date/time are reported in this file. As with the data for the SURFACE pathway, both the value and bound or missing indicator may have been multiplied by a factor to integerize and retain significant digits. The user should review the message file to determine if the violations are errors in the data and need correction or if they can be ignored. The total number of violations and missing values are summarized by variable in the REPORT file, UPPERAIR.RPT.

AERMET does not modify the data during the QA. If the quality assessment identifies any problems, then either the EXTRACT file (UAEXOUT.DSK) or the QAOUT file (UAQAOUT.DSK) may be edited to manually correct the data in accordance with meteorological principles and within any relevant regulatory guidelines. If the modifications are extensive, the data should be reprocessed through the quality assessment procedures to identify any problems that may be introduced with the modifications.

There are several optional keywords available for the UPPERAIR pathway. These are:

RANGE - modifies the default QA bounds and missing value indicator for the variable specified;

NO_MISSING - suppresses the message that data are missing for variables being audited during the QA process; this keyword is useful in reducing the size of the message file if an audited variable is missing most of the time.

MODIFY - directs to perform automatic modifications to the upper air data as the data are extracted; these modifications are described in Section 4 with the discussion of this keyword.

A detailed discussion of each of the keywords on the UPPERAIR pathway is provided in Section 4, with a synopsis of each in Appendix A.

2.2.2.2 Running Stage 1 and reviewing the output

To run STAGE1N2 with EX1-UA.INP to extract and QA the NWS upper air soundings, the following commands are typed at a DOS prompt[2]:

COPY EX1-UA.INP STAGE1N2.INP

STAGE1N2

The executable and version date, setup processing, and data processing are displayed on the screen as described in Section 2.2.1.3.

Figure 2-7 shows the message file that results from running EX1-UA.INP. Most of the messages are easily interpreted and are related to the data QA. The structure of these messages is explained in Appendix D.

```
       JOB        I19  SETUP: FOUND "END OF FILE" ON UNIT  5 AFTER RECORD # 11
       JOB        I26   TEST: SUMMARY: NO DATA EXTRACTION FOR SURFACE
       JOB        I26   TEST: SUMMARY: NO DATA QA FOR SURFACE
       JOB        I27   TEST: SUMMARY: NO DATA QA FOR ONSITE
       UPPERAIR   I30  UAEXT: **** UPPER AIR EXTRACTION ****
       UPPERAIR   I39 GETSDG: END-OF DATA WINDOW ENCOUNTERED
       UPPERAIR   I39  UAEXT:  20 SOUNDINGS EXTRACTED
880301 UPPERAIR   Q35 UAQASM: COULD NOT RECOMPUTE HTS. FOR HR 19
880302 UPPERAIR   Q39 UAQASM: UAWS MISSING FOR HR 07 AT LEVEL  8
880302 UPPERAIR   Q39 UAQASM: UAWS MISSING FOR HR 07 AT LEVEL  9
880302 UPPERAIR   Q39 UAQASM: UAWS MISSING FOR HR 07 AT LEVEL 10
880304 UPPERAIR   Q37 REALQA: LB: UALR=  -4.444 <    -2.000 FOR HR 19, LVL  8
880306 UPPERAIR   Q38 REALQA: UB: UALR=   5.714 >     5.000 FOR HR 07, LVL  2
880306 UPPERAIR   Q38 REALQA: UB: UALR=   5.065 >     5.000 FOR HR 07, LVL  3
880309 UPPERAIR   Q37 REALQA: LB: UALR=  -3.000 <    -2.000 FOR HR 19, LVL  2
880310 UPPERAIR   Q38 REALQA: UB: UALR=   5.897 >     5.000 FOR HR 07, LVL  9
       UPPERAIR   I39 UAQASM: EOF AFTER UPPERAIR SOUNDING #  20
```

FIGURE 2-7. MESSAGE FILE FROM PROCESSING NWS UPPER AIR DATA.

The first four messages are informational messages, as denoted by the 'I' in the first position in the third field, and pertain to the runstream setup processing. The first message indicates that 11 records were processed (including blank and comment lines) before encountering an end of file on the input runstream. This is usually the first record in the message file. The next three records indicate actions that will not be performed and relate to the SURFACE and ONSITE pathways. The remaining messages pertain to the processing of the NWS twice-daily upper air data. Records 5 through 7 indicate that data were extracted for the

[2] See Section 2.2 for a discussion on file redirection using the "<" symbol.

UPPERAIR pathway and that 20 soundings were extracted. This value can be used to determine if the correct number of soundings were processed. In this example, since the XDATES keyword specified the 10-day period March 1-10, the correct number of soundings were extracted (10 days x 2 soundings/day). These informational messages are followed by QA messages, as denoted by the 'Q' in the first position of the third field. The number at the left of the message indicates the year, month, and day of the QA violation and the hour is contained in the body of the message. The final record in this file is another informational record indicating that the end of file on the input file was encountered after sounding number 20, the same number of soundings that were extracted.

There are two types of QA violations and one type of processing 'problem' reported here. The processing problem is identified in record eight. Using the hypsometric equation, AERMET will attempt to recompute the upper air sounding heights to confirm that the height of each level in the sounding is reasonable (see Section 5.1 for a complete discussion). If one or more pieces of the data required to perform this calculation are missing, then AERMET skips the calculation and issues this message. The user should check the sounding in question to confirm that there aren't any serious data errors in the sounding. This message may not require any user modification to the data if the computations in Stage 3 are not affected (currently AERMET only requires height, pressure, and temperature from the soundings). Records 9 through 11 indicate that the wind speed, as denoted by the variable name UAWS (see Table B-3 for a list of UPPERAIR variable names), was missing for the 0700 LST sounding on March 3, 1988 at levels 8, 9 and 10. Since wind speed is not currently used in any calculations, these messages only serve as an indicator of the quality of the wind data.

Records 12 through 16 relate to the change in temperature, or lapse rate, between two levels of data, as denoted by the variable name UALR in the body of the message. The format of these five messages is similar for all upper and lower bound violation messages that the upper air QA generates. The messages contain the following information:

Field 1: the sounding date
Field 2: the pathway
Field 3: the message code
Field 4: the subroutine that issued the message
Field 5: the message

- LB: = lower bound violation
- UB: = upper bound violation
- UALR= variable in question, the lapse rate in this example
- calculated value < lower bound or calculated value > upper bound
- hour of the sounding in LST
- between the level reported in the message and the level below

AERMET calculates the lapse rate and, if the result is outside a range of values, AERMET issues a QA message. In the first of these messages, a lapse rate of -0.0444 K/m was computed (and multiplied by 100) and compared to the default value of -0.02 K/m (also multiplied by 100 in Table B-1). Since -0.0444 < -0.02, the message was written. There are default values in AERMET (see Table B-1) but these bounds can be redefined using the RANGE keyword (as described earlier and in Section 4).

None of these messages indicate anything extremely unusual during the QA of the sounding data but, nonetheless, the user should review the data to confirm this assumption.

Figures 2-8a through 2-8c show the summary report for the run. The first two figures are similar in content to Figures 2-4a and 2-4b for the SURFACE pathway. However, Figure 2-8c with the QA summary appears different because there are several levels of data per sounding. The page begins with the AERMET banner and is followed by the message that the data processing finished successfully. Below this heading is a table that is divided into layer thicknesses: surface, eight layers that are 500 meters thick, and all data above 4000 meters. The reason for this division is that the height at which upper air data are reported varies from sounding to sounding, except that there is always a level at the surface. The general structure of the table is identical to the table for the summary of the QA of hourly surface observations with the variable name and violation summary on the left and the test values used for the QA on the right. Only the variables that were included with the AUDIT keywords appear in this table because none of the upper air variables are automatically QA'd. Examining the table reveals that there were three missing wind speeds in the 500-1000 meter layer, two lower bound violations and three upper bound violations, which corresponds to the number of individual messages written to the message file (Figure 2-7). Also note that the lapse rate is not reported for the surface. None of the variables that compute a change between layers (wind shear, lapse rates) can be reported for the surface.

Below the table is a report on several other conditions that AERMET checks: calm winds, zero wind speed and a nonzero wind direction, dew point temperature greater than ambient air temperature, and the number of soundings that do not extend to 5000 meters. The first three are identical to the checks made for the hourly surface observations. AERMET extracts sounding data from an archive file up to the first level above 5000 meters. The last check reports the number of soundings where the top of the sounding was below 5000 meters. The date and time of such a sounding is reported in the message file. In Stage 3, AERMET extrapolates the heights to 5000 meters for these "low" soundings if it becomes necessary in order to complete the boundary layer parameter estimates. This extrapolation process is explained in Section 5.4.4.

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                   Version  98314

                    Data Processed on 11-NOV-98 at 08:41:06

              ********************************************************
              ***         AERMET Setup Finished Successfully        ***
              ********************************************************

  1.  Job File Names

      Listing of Messages: UPPERAIR.MSG
      Summary (this file): UPPERAIR.RPT


  2.  Upper Air Data

       Site ID    Latitude(deg.)   Longitude(deg.)   Conversion to LST
      00014735       42.75N           73.80W               5

      AERMET Has Determined That Processing For This Pathway Includes:
           EXTRACT AND QUALITY ASSESSMENT

           Extract Input -    OPEN: 14735-88.UA
           Extract Output-    OPEN: UAEXOUT.DSK
           QA Output     -    OPEN: UAQAOUT.DSK

           The Extract Dates Are:    Starting:  1-MAR-88
                                       Ending: 10-MAR-88

           Upper Air Data Above the First Level Above 5000 Meters Not Extracted
           Upper Air Automatic Data Checks Are: OFF


  3.  NWS Surface Data

      AERMET Has Determined That Processing For This Pathway Includes:
           NONE, NO DATA TO BE PROCESSED ON THIS PATH



  4.  On-site Data

      AERMET Has Determined That Processing For This Pathway Includes:
           NONE, NO DATA TO BE PROCESSED ON THIS PATH
```

FIGURE 2-8a. FIRST PART OF THE REPORT FILE FROM PROCESSING UPPER AIR SOUNDINGS.

```
AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                         Version  98314

              Data Processed on 11-NOV-98 at 08:41:07

        ********************************************************
        ***   AERMET Data Processing Finished Successfully   ***
        ********************************************************

             EXTRACT AND/OR QA THE METEOROLOGICAL DATA


              **** AERMET MESSAGE SUMMARY TABLE ****

       0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
      ----------------------------------------------------------------------

 JOB
   E    0       0       0       0       0       0       0       0       0
   W    0       0       0       0       0       0       0       0       0
   I    0       1       3       0       0       0       0       0       4

 UPPERAIR
   E    0       0       0       0       0       0       0       0       0
   W    0       0       0       0       0       0       0       0       0
   I    0       0       0       4       0       0       0       0       4
   Q    0       0       0       9       0       0       0       0       9
      ----------------------------------------------------------------------
        0       1       3      13       0       0       0       0      17

     ****    ERROR MESSAGES  ****

           ---  NONE  ---


     ****   WARNING MESSAGES ****

           ---  NONE  ---
```

FIGURE 2-8b. SECOND PART OF THE REPORT FILE FROM PROCESSING UPPER AIR SOUNDINGS.

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                 Version  98314

                      Data Processed on 11-NOV-98 at 08:41:06

               *******************************************************
               ***   AERMET Data Processing Finished Successfully   ***
               *******************************************************

                        **** SUMMARY OF THE QA AUDIT ****

     SOUNDINGS         |------VIOLATION SUMMARY------|   |-----TEST VALUES-----|
               TOTAL     #     LOWER  UPPER     %      MISSING   LOWER   UPPER
               # OBS  MISSING  BOUND  BOUND  ACCEPTED    FLAG    BOUND   BOUND
             SURFACE
        UATT      20        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      20        0      0      0    100.00     9990.0,    0.0,  500.0
           0 -  500M
        UATT      67        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      67        0      0      0    100.00     9990.0,    0.0,  500.0
        UALR      67        0      1      2     95.52    -9999.0,   -2.0,    5.0
         500 - 1000M
        UATT      48        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      48        3      0      0     93.75     9990.0,    0.0,  500.0
        UALR      48        0      0      0    100.00    -9999.0,   -2.0,    5.0
        1000 - 1500M
        UATT      44        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      44        0      0      0    100.00     9990.0,    0.0,  500.0
        UALR      44        0      1      0     97.73    -9999.0,   -2.0,    5.0
        1500 - 2000M
        UATT      51        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      51        0      0      0    100.00     9990.0,    0.0,  500.0
        UALR      51        0      0      1     98.04    -9999.0,   -2.0,    5.0
        2000 - 2500M
        UATT      52        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      52        0      0      0    100.00     9990.0,    0.0,  500.0
        UALR      52        0      0      0    100.00    -9999.0,   -2.0,    5.0
        2500 - 3000M
        UATT      32        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      32        0      0      0    100.00     9990.0,    0.0,  500.0
        UALR      32        0      0      0    100.00    -9999.0,   -2.0,    5.0
        3000 - 3500M
        UATT      30        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      30        0      0      0    100.00     9990.0,    0.0,  500.0
        UALR      30        0      0      0    100.00    -9999.0,   -2.0,    5.0
        3500 - 4000M
        UATT      21        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      21        0      0      0    100.00     9990.0,    0.0,  500.0
        UALR      21        0      0      0    100.00    -9999.0,   -2.0,    5.0
            > 4000M
        UATT      79        0      0      0    100.00    -9990.0, -350.0,  350.0
        UAWS      79        0      0      0    100.00     9990.0,    0.0,  500.0
        UALR      79        0      0      0    100.00    -9999.0,   -2.0,    5.0

  NOTE: Test values were also multiplied by the same factors applied to the data
        (see Appendix B of the AERMET User's Guide)

         In addition, for the   20 soundings, AERMET reports that there are:

              0 CALM WIND CONDITIONS (WS=0, WD=0)
              0 ZERO WIND SPEEDS WITH NONZERO WIND DIRECTIONS
              0 DEW POINT GREATER THAN DRY BULB TEMPERATURE
              0 SOUNDINGS THAT DO NOT EXTEND TO  5000 METERS

         The date, time and level of the occurrences for the first three
         can be found in the message file  UPPERAIR.MSG
         with qualifiers CLM, WDS, TDT (resp.)
```

FIGURE 2-8c. THIRD PART OF THE REPORT FILE FROM PROCESSING UPPER AIR SOUNDINGS.

2.2.3 Stage 2 - Merging Data

In Stage 2, the data processed in Stage 1 are merged (combined) into a single, formatted ASCII file with the data grouped in 24-hour periods (in local standard time). Figure 2-9 shows the processing flow associated with Stage 2 for this example. In this step, the NWS hourly surface observations and upper air soundings are combined. Figure 2-10 shows the runstream for Stage 2 and is provided in the file EX1-MRG.INP.

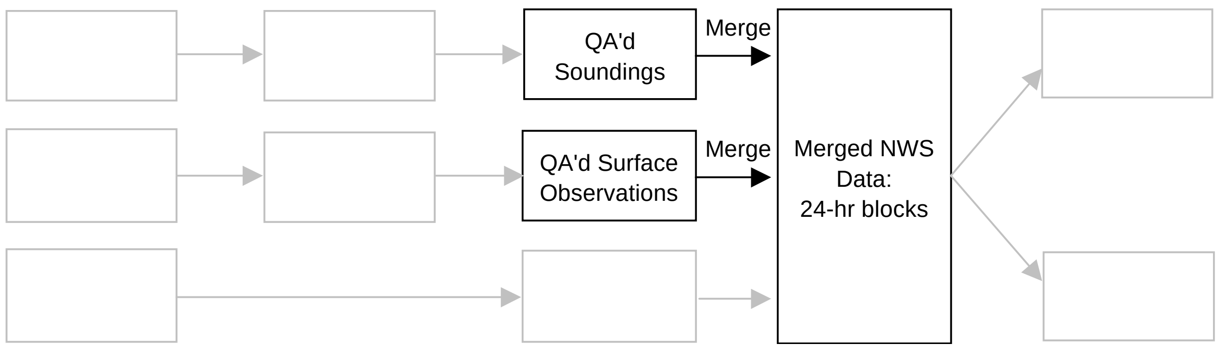

FIGURE 2-9. STAGE 2 PROCESSING THAT MERGES THE HOURLY SURFACE OBSERVATIONS AND UPPER AIR SOUNDINGS INTO A SINGLE FILE.

```
JOB                                     Start of the JOB pathway

  REPORT     MERGE-1.RPT                File for all messages

  MESSAGES   MERGE-1.MSG                File for run summary

SURFACE                                 Start of the SURFACE pathway

  QAOUT      SFQAOUT.DSK                Input file with NWS hourly
observations

UPPERAIR                                Start of the UPPERAIR pathway

  QAOUT      UAQAOUT.DSK                Input file with NWS upper air data

MERGE                                   Start of the MERGE pathway

  OUTPUT     MERGE.DSK                  Output file with merged
                                        meteorological data

  XDATES     88/03/01  88/03/04         Period to include in the output
file
```

FIGURE 2-10. EXAMPLE RUNSTREAM TO MERGE NWS DATA.

Merging data must be executed as a stand-alone process. Neither Stage 1 extraction/QA nor Stage 3 data processing can be performed with the merge. If the user attempts such a combination, AERMET issues an error message and does not process any data.

The only valid keywords for the MERGE pathway are:

OUTPUT - specifies the output file name of merged data/input file name for Stage 3;

XDATES - an optional keyword that specifies the period of time to be retrieved from the input files and merged together.

The OUTPUT keyword defines the file to which the merged data are written. It is an ASCII file. In this example, the output is written to MERGE.DSK.

The range of dates in the files that are to be combined are specified using the XDATES keyword. The syntax is identical to its usage in the extract and QA processes in Stage 1. Notice in this example the optional "TO" has been omitted. By using the XDATES keyword, a subset of the data can be merged. This is useful if the user had processed a large amount of data (e.g., one year of data), but is interested in a shorter time period for dispersion modeling. In this example, data between March 1, 1988 and March 4, 1988, inclusive, are merged (recall that data for the period March 1 - March 10 were processed in Stage 1 for both SURFACE and UPPERAIR data).

The XDATES keyword is optional and if it is omitted, then AERMET begins merging data corresponding with the earliest date found in the input data files. The ending date is always 367 days later, even if the last day of data in all the input files is prior to the 367th day. The user can determine if there are days without data by examining the summary file as explained at the end of this subsection.

The input files to Stage 2 are specified with the QAOUT keyword for the appropriate pathway. The example in Figure 2-10 uses the two files that were created from the QA process for the SURFACE and UPPERAIR pathways above. The QAOUT keywords are the only allowable keywords for the SURFACE and UPPERAIR pathways when data are merged. The algorithms in Stage 3 require certain meteorological data to compute the boundary layer parameters. A merge cannot be performed with NWS upper air data alone. AERMET interprets this situation as an error and will not process any data.

2.2.3.1 Running Stage 2 and reviewing the output

The merge process is run with the executable STAGE1N2.EXE. To merge the data using EX1-MRG.INP, the following commands are typed at a DOS prompt on the PC:

```
COPY EX1-MRG.INP STAGE1N2.INP
STAGE1N2
```

The executable and version date, setup processing, and data merging are displayed on the screen as described in Section 2.2.1.3.

The message file for Stage 2 (Figure 2-11) is very brief: the actions AERMET will not perform and the total number of header records processed from the input files.

```
JOB        I19  SETUP: FOUND "END OF FILE" ON UNIT  5 AFTER RECORD # 13
JOB        I25   TEST: SUMMARY: NO DATA EXTRACTION FOR UPPERAIR
JOB        I25   TEST: SUMMARY: NO DATA QA FOR UPPERAIR
JOB        I26   TEST: SUMMARY: NO DATA EXTRACTION FOR SURFACE
JOB        I26   TEST: SUMMARY: NO DATA QA FOR SURFACE
JOB        I27   TEST: SUMMARY: NO DATA QA FOR ONSITE
JOB        I27   TEST: SUMMARY: NO DATA TO MERGE FOR ONSITE
    26 HEADERS PROCESSED FROM INPUT FILES
```

FIGURE 2-11. MESSAGE FILE FROM MERGING THE NWS DATA.

Figures 2-12a through 2-12c show the summary report for the Stage 2 run. Like the previous runs, the first page of output echoes the input in a more readable format. In Figure 2-12a, notice that the station locations have been included for the SURFACE and UPPERAIR pathways even though they were not specified in the runstream (Figure 2-10). Recall that the general output file structure (Section 1.1.4) includes header records, which are the runstream records with additional characters at the beginning of each record. AERMET reads all these input file header records. If a header record contains a special character at the beginning of the record (inserted by AERMET at the time the record was written to the output file), then AERMET reprocesses the record as if it had been included in the runstream. This is the case with the LOCATION keywords for the SURFACE and UPPERAIR pathways and why this information appears in the summary of the merge process.

The second page of the output is shown in Figure 2-12b and contains something that has not been seen before. AERMET produces a table with the number of observations merged by pathway for each day. Since only the period March 1-4 was specified with the XDATES keyword, only four days appear in this table which is also noted just above the table. The structure of this table and explanation of each line is as follows:

1) The month and day - up to 10 days per four-record grouping.

2) Number of soundings merged per day; although the soundings normally are reported twice per day, AERMET also includes the afternoon sounding from the previous day and the morning sounding for the next day. Since the upper air sounding data were extracted beginning with March 1, there is no previous afternoon sounding (on 2/29/88) to include in the merged data; hence only three soundings were merged on 3/1/88.

3) Number of hourly surface observations - since there are 24 each day, there were no days with any missing hourly surface data.

4) Number of hourly site-specific data observations - since there were no site-specific data in the data base, the last line in the table contains all zeroes.

If there are more than 10 days in the merged data file, then another group of records would have appeared below the first. One year of data requires nearly 200 records.

Below this table is a summary of the number observations <u>read</u> (but not necessarily merged) from each input file. Note that AERMET read 98 hourly surface observations rather than 96 (4 days x 24 hours/day) to create the merged data file. There are two reasons for these extra observations to be read (but not merged). First, for the CD-144 format, the initial hour in the file is hour 0 on March 1, which is equivalent to hour 24 of the previous day (February 29). AERMET operates on the 1-to-24 hour clock, so the first record is read but not merged. Secondly, the first record on March 5 is read before AERMET determines that the hourly surface data are outside the period specified with the XDATES keyword, hence it is not included in the merged data file. Hence, two additional records were read to merge 96 hours (four days) of data.

The third page of the summary is shown in Figure 2-12c and contains the message summary table. Since no messages associated directly with the merge process were written to the message file, there isn't a separate block (with all 0's) for the MERGE pathway.

```
     AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  98314

                 Data Processed on 11-NOV-98 at 11:38:40

             ********************************************************
             ***        AERMET Setup Finished Successfully        ***
             ********************************************************

 1.  Job File Names

     Listing of Messages: MERGE-1.MSG
     Summary (this file): MERGE-1.RPT


 2.  Upper Air Data

      Site ID    Latitude(deg.)   Longitude(deg.)   Conversion to LST
     00014735       42.75N            73.80W                5

     AERMET Has Determined That Processing For This Pathway Includes:
          MERGE ONLY

          QA Output     -    OPEN: UAQAOUT.DSK


 3.  NWS Surface Data

      Site ID    Latitude(deg.)   Longitude(deg.)   Conversion to LST
        14735       42.75N             73.8W                0

     AERMET Has Determined That Processing For This Pathway Includes:
          MERGE ONLY

          QA Output     -    OPEN: SFQAOUT.DSK


 4.  On-site Data

     AERMET Has Determined That Processing For This Pathway Includes:
          NONE, NO DATA TO BE PROCESSED ON THIS PATH



 5.  Merged Data
          Merge Output  -    OPEN: MERGE.DSK
```

FIGURE 2-12a. FIRST PART OF THE SUMMARY FILE FOR THE MERGE PROCESSING.

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                  Version  98314

                        Data Processed on 11-NOV-98 at 11:38:40

                           Merging the Meteorological Data

                        Merged Data Begin (Yr/Mo/Da) 88/ 3/ 1
                                      End            88/ 3/ 4

                     ***** Daily Output Statistics *****
                 MO/DA  3/ 1  3/ 2  3/ 3  3/ 4
   NWS  Upper Air  Sdgs   3     4     4     4
   NWS Sfc Observations  24    24    24    24
   On-site Observations   0     0     0     0

        Upper Air Obs. Read:    9
        Surface Obs. Read:     98
        On-site Obs. Read:      0

                     ***** MERGE PROCESS COMPLETED *****
```

FIGURE 2-12b. SECOND PART OF THE SUMMARY FILE FOR THE MERGE PROCESSING.

```
      AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                              Version  98314

                   Data Processed on 11-NOV-98 at 11:38:41

             *******************************************************
             ***   AERMET Data Processing Finished Successfully   ***
             *******************************************************


                    **** AERMET MESSAGE SUMMARY TABLE ****

         0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
        ----------------------------------------------------------------------

   JOB
     E   0       0       0       0       0       0       0       0       0
     W   0       0       0       0       0       0       0       0       0
     I   0       7       0       0       0       0       0       0       7
        ----------------------------------------------------------------------
         0       7       0       0       0       0       0       0       7

       ****    ERROR MESSAGES  ****

              ---  NONE  ---


       ****   WARNING MESSAGES ****

              ---  NONE  ---
```

FIGURE 2-12c. THIRD PART OF THE SUMMARY FILE FOR THE MERGE PROCESSING.

2.2.4 Stage 3 - Estimating Boundary Layer Parameters for AERMOD

With all the NWS meteorological data merged into one file, Stage 3 can be run to generate the two input files for AERMOD, as shown in Figure 2-13.

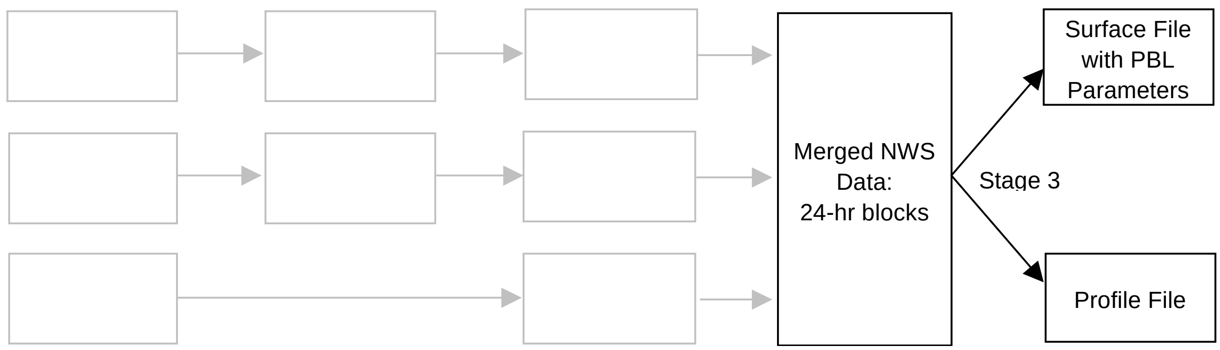

FIGURE 2-13. STAGE 3 PROCESSING USING THE MERGED NWS DATA TO CREATE THE INPUT METEOROLOGY FOR AERMOD.

The meteorological data for AERMOD are generated in Stage 3, which is executed using the executable program STAGE3.EXE. The input runstream file can only include statements for the JOB and METPREP pathways. It is the statements for the METPREP pathway that control the Stage 3 processing. An example runstream is shown in Figure 2-14 and is provided in the file EX1-ST3.INP.

```
JOB                                         Start of the JOB pathway

  REPORT     STAGE3-1.RPT                   File for all messages

  MESSAGES   STAGE3-1.MSG                   File for the run summary


METPREP                                     Start of the METPREP pathway

  DATA              MERGE.DSK                      Input meteorological data
                                                   file from Stage 2

  LOCATION   MYSITE   74.ØØW  41.3N  5      Station identifier and location
                                            information

  METHOD     REFLEVEL SUBNWS                Processing method: allow
                                            substitution of NWS data

  METHOD     WIND_DIR RANDOM                Processing method: randomize NWS
                                            wind directions

  NWS_HGT    WIND      6.1                         NWS wind measurement height

  OUTPUT     AERMET.SFC                     Output file with boundary layer
parameters

  PROFILE    AERMET.PFL                     Output file with profile data

  FREQ_SECT  ANNUAL       1                        Frequency and number of wind
                                                   direction sectors to define
                                                   the site characteristics

  SECTOR     1      Ø      36Ø              Definition of wind direction
sectors

  SITE_CHAR  1      1      Ø.15   2.ØØ   Ø.12   Definition of site
                                                   characteristics by period
                                                   and wind direction sector
```

FIGURE 2-14. EXAMPLE RUNSTREAM TO CREATE THE OUTPUT FILES FOR AERMOD.

The keywords used in this example are:

DATA - specifies the input file name of the merged data from Stage 2;

LOCATION - specifies a site identifier, latitude and longitude, and the factor to convert the time of each record from local standard time to GMT;

NWS_HGT - specifies the instrument height for the variable indicated;

METHOD - defines a specific processing methodology for the secondary keyword specified with this keyword;

OUTPUT - specifies the output file of fluxes, scaling parameters, mixing height, near-surface winds and temperature;

PROFILE - specifies the output file of the multi-level observations of temperature, winds and fluctuating components of the wind;

FREQ_SECT - specifies the frequency and number of wind direction sectors for defining the site-specific characteristics of surface roughness length, albedo and midday Bowen ratio; this keyword <u>must</u> appear before the next two keywords;

SECTOR - specifies the lower and upper bounds of individual wind direction sectors; up to 12 sectors can be defined and the directions so specified must account for all directions;

SITE_CHAR - defines the albedo, midday Bowen ratio and surface roughness length by frequency and sector (in that order);

DATA, OUTPUT, and PROFILE

The input data file created by Stage 2, MERGE.DSK, is identified through the DATA keyword. The OUTPUT and PROFILE keywords define the output files that will be used as input to the AERMOD dispersion model. In this example, the two files are AERMET.SFC and AERMET.PFL, respectively. The output files are ASCII files and can be viewed with a text editor or file viewer. The format of these two output files is given in Appendix D. Each record of the OUTPUT file contains the surface fluxes of heat and momentum, scaling and stability parameters, boundary layer height, and the site's surface characteristics, winds and temperature that were used to compute these values. The PROFILE file usually consists of one or more levels of wind, temperature and standard deviations of the wind from an site-specific observation program or from NWS data if site-specific data are missing or not in the data base.

LOCATION

The processing carried out in Stage 3 is location-dependent. The application site is likely to be different from either of the meteorological sites specified for the SURFACE and UPPERAIR data. The latitude and longitude entered here are used to calculate the elevation of the sun and the times of sunrise and sunset. It is very important to

☞ **specify the latitude and longitude for the application site.**

The LOCATION keyword is used for this purpose. The site identifier, "MYSITE" in this case, is required but is not used in AERMET. It is simply an aid in remembering to which site the runstream is being applied. As in previous usage, the latitude and longitude can be specified in either order and must use the N, S, E, W suffixes to place the location relative to the equator and Greenwich. The last item on this statement is used internally to find the 1200 GMT sounding. Since the sounding times were converted from GMT to local time in Stage 1, this factor is added to the local time in order to determine which sounding is the 1200 GMT sounding. As in Stage 1, this conversion factor is a positive number. The value of this parameter should match the value entered on the LOCATION keyword for the UPPERAIR pathway when the data were extracted in Stage 1. Failure to use the same conversion factor could result in not locating the 1200 GMT sounding in the data. If this parameter is omitted, then a default value of 0 is assumed and it is likely that AERMET will not locate the sounding in the data. See also Section 4.7.3 for an additional discussion on sounding times.

To estimate the convective mixing heights, AERMET requires an early morning sounding each day. This limitation precludes using this version of AERMET in regions outside the western hemisphere.

METHOD

The METHOD keyword and associated secondary keywords direct AERMET to process the data in a particular manner. Depending on the data in the data base and the intended use for the output, this keyword may be optional or mandatory. The METHOD keyword becomes increasingly important when NWS observations are the only source of input meteorological data.

In this example, both secondary keywords currently available in AERMET are used: REFLEVEL and WIND_DIR. The REFLEVEL secondary keyword takes a single parameter. The only valid parameter is SUBNWS which directs AERMET to substitute NWS data in the computations in the event there are no site-specific data to use. If there are no site-specific data in the data base, this secondary keyword becomes mandatory. If it is omitted, AERMET detects this condition (no site-specific data and do not substitute NWS data) as an error and will not process any data. If there are site-specific data in the data base, but some of the variables required for the computations are missing, then this parameter directs AERMET to use the NWS data to estimate the boundary layer parameters. Also, if the site-specific profiles of wind or temperature are missing, this parameter directs AERMET to use NWS data to create the profile of wind and/or temperature.

NWS wind directions are recorded to the nearest 10 degrees. The WIND_DIR secondary keyword directs AERMET to randomize these directions if the RANDOM parameter is specified or to leave the directions as they were extracted from the archive file if the NORAND parameter is specified. The default is not to randomize, so if this secondary keyword is omitted, then any NWS wind directions will appear to the nearest 10 degrees (equivalent to specifying NORAND). This example uses the RANDOM parameter and all NWS wind directions used in the computations and written to the output files are randomized. The EPA's standard table of random integers, which is built into AERMET, is used to randomize wind direction.

NWS_HGT

Many computations in AERMET require the height at which a variable was measured. If NWS data are the only data in the data base, as in this example, then this keyword is mandatory to define these heights for AERMET. The NWS_HGT keyword serves this purpose. This keyword requires a secondary keyword and parameter. The secondary keyword identifies the instrument that is being referenced and the parameter defines the height of the instrument, which must be specified in meters. Currently, there is only one weather variable that uses this keyword - wind; and the secondary keyword is WIND. Typically, the measurement height can range anywhere from about 20 feet (6.1 meters), which has been the standard height at NWS sites, to 30 feet (9.1 meters) for more recent measurements at some NWS sites. The *Local Climatological Data Annual Summaries* available from NCDC contain a historical record of instrumentation sites and measurement heights for the stations included in the five volume set. In this example, the height of the anemometer that measures the wind is at 6.1 meters (20 feet).

NWS_HGT is a mandatory keyword if the REFLEVEL secondary keyword is used with the SUBNWS parameter. Otherwise, the NWS_HGT keyword can be omitted.

FREQ_SECT, SECTOR, and SITE_CHAR

The algorithms in Stage 3 require site-specific characteristics about the underlying surface where AERMOD is to be applied: the noon-time albedo, daytime Bowen ratio, and surface roughness length. Three keywords define these surface characteristics: FREQ_SECT, SECTOR, and SITE_CHAR. These keywords are mandatory. There is no other method to specify this information for AERMET (e.g., through a data file).

The FREQ_SECT keyword has two parameters associated with it: the first defines the frequency with which the site characteristics vary and the second defines the number of contiguous, nonoverlapping wind direction sectors that define unique upwind surface characteristics.

☞ **The FREQ_SECT keyword must precede the SECTOR and SITE_CHAR keywords**.

There are three valid time frequencies: ANNUAL, SEASONAL, or MONTHLY. For program operation, the definition of SEASONAL in AERMET follows the calendar rather than any vegetation cycles. Winter corresponds to December, January and February; spring corresponds to March, April and May; summer corresponds to June, July and August; and autumn corresponds to September, October and November. The user will have to determine how the definitions of the seasons in the tables relate to vegetation cycles for a particular application. Currently, there is no method in AERMET to specify the surface characteristics more frequently than monthly.

In this example, the surface characteristics are to be defined with a frequency of ANNUAL for one distinct wind direction sector; i.e., only the three surface characteristics are changed while the default frequency and sector definition are retained. If the maximum frequency and sectors had been defined, then it would require 144 (12 frequencies and 12 sectors) uses of the SITE_CHAR keyword to completely define the surface characteristics. An example of MONTHLY characteristics for two sectors in given in Section 3.

The SECTOR keyword defines the beginning and ending directions of each sector, with one sector defined on each use of the keyword. There are a few rules to follow when specifying the sectors:

1) The sectors are defined clockwise as the direction from which the wind is blowing, with north corresponding to 360°.

2) The sectors must cover the full circle, and these must be defined so that the end of one sector is the beginning of another, i.e., for multiple sector definitions, the beginning value for one sector must match the end value of the previous sector.

3) The beginning direction is considered part of the sector, while the ending direction is excluded from the sector.

One SECTOR keyword is required in this example because '1' was specified with the FREQ_SECT keyword. The sector must be 0° - 360° so as not to violate rule 2 above.

The surface characteristics are specified with the SITE_CHAR keyword, one for each combination of periods defined by the frequency and direction sector. The parameters associated with this keyword are:

1) the time period corresponding with the frequency on the FREQ_SECT keyword;

2) wind sector index;

3) the midday albedo (nondimensional);

4) daytime Bowen ratio (nondimensional);

5) surface roughness length (meters).

These parameters are used in the computation of the fluxes and stability of the atmosphere. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Typical values range from 0.1 for thick deciduous forests to 0.90 for fresh snow. The Bowen ratio, an indicator of surface moisture, is the ratio of the sensible heat flux to the latent heat flux. Although the Bowen ratio can have significant diurnal variation, it is used to determine the planetary boundary layer parameters for convective conditions. During the daytime, the Bowen ratio usually attains a fairly constant positive value, which range from about 0.1 over water to 10.0 over desert at midday. The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero. Values range from less than 0.001 meter over a calm water surface to 1 meter or more over a forest or urban area.

Tables 4-1 to 4-3 (from Paine, 1987) show typical values of the albedo, Bowen ratio and surface roughness length as a function of season and land use type. The season in these tables are based on the emergence and growth of vegetation. For example, March in one part of the country may represent spring whereas in another part of the country it may well be winter. See Sections 4.7.7 and 5.4.2 for additional discussions on the surface characteristics.

Optional keywords that are available for Stage 3 processing are:

XDATES -	restricts the processing to a subset of the input data;
MODEL -	specifies the dispersion model for which the estimates are made; currently AERMET only generates the meteorological data for AERMOD, so this keyword is optional.

A detailed discussion of each of the keywords on the METPREP pathway is provide in Section 4, with a synopsis of each in Appendix A.

2.2.4.1 Running Stage 3 and reviewing the output

To run Stage 3 to create the meteorological files for AERMOD, the following command lines are used:

```
COPY EX1-ST3.INP STAGE3.INP
STAGE3
```

where EX1-ST3.INP is the example runstream file name. The discussion for STAGE1N2 on redirecting output (Section 2.2) also applies to STAGE3. The executable and version date, setup processing, and data processing are displayed on the screen as described in Section 2.2.1.3.

Figure 2-15 shows the message file that results from running EX1-ST3.INP. The file begins with the familiar message that the end of file was located after record number 12. This message is followed by eight messages that the boundary layer parameters were not computed for the specified date (leftmost) field and time (at the end of the message) due to calm winds. When calm wind conditions are encountered, AERMET does not perform any computations and inserts missing data indicators into the output files for the boundary layer parameters (see Figure 2-17 for an example of the output file). The final message indicates that AERMET encountered an end of file on the input meteorological data, i.e., on the merged data file, after March 4, 1988. Since March 1-4, 1988 were the only days merged, this message indicates that all the data appear to have been processed.

```
       METPREP    I19 ST3SET: "END OF FILE" ON UNIT  5 AFTER RECORD #  15
880302 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 02
880302 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 03
880302 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 04
880302 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 05
880302 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 06
880302 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 07
880303 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 19
880303 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 21
     5 METPREP    I79  FETCH: EOF ON INPUT DATA FILE AFTER 880304
```

FIGURE 2-15. MESSAGE FILE FROM STAGE3 FOR EX1-ST3.INP.

The summary of the run is shown in Figures 2-16a and 2-16b. The first page, in Figure 2-16a, begins with the AERMET banner and is followed by:

1. The names of the input and output files and whether the files were opened.

2. The name of the dispersion model for which the data are prepared.

3. The processing options (keyword METHOD).

4. The site identifiers and locations for each of the meteorological data pathways (since there was no site-specific data, the site identifier is denoted by periods); these data are followed by the latitude and longitude that were specified with the LOCATION keyword in EX1-ST3.INP and are used in the computations in Stage 3.

5. The site-specific surface characteristics.

6. The output file names for the dispersion model identified.

The second page, in Figure 2-16b, shows the message summary table. There is no summary for the JOB pathway because all the messages shown in Figure 2-15 are associated with the METPREP pathway. Below this table is a listing of the warning messages that AERMET generated while processing the meteorological data and wrote to the message file. The messages in this example pertain to calm winds that were identified in the message file.

Figure 2-17 shows the first 36 hours from the boundary layer parameter file. The first record contains the latitude and longitude used in processing the meteorological data in Stage 3, the station identifiers, and the AERMET version date. The identifier after OS_ID: is a 0 because no site-specific data were processed. The OS_ID is <u>not</u> the identifier specified in the Stage 3 runstream; the three identifiers that are displayed come from the processing in Stage 1. This record is followed by one record per hour of meteorological output data. The contents of this file are:

field(s)	description
1-5	year (2-digit), month, day, Julian day, and hour
6	sensible heat flux (W m^{-2})
7	surface friction velocity (m s^{-1})
8	convective velocity scale (set to -9.0 for stable atmosphere) (m s^{-1})
9	potential temperature gradient above the mixing height (K m^{-1})
10	convectively-driven mixing height (-999. for stable atmosphere) (m)
11	mechanically-driven mixing height (computed for all hours) (m)
12	Monin-Obukhov length (m)
13	surface roughness length (month and wind direction dependent) (m)
14	Bowen ratio (month and wind direction dependent) (non-dimensional)
15	albedo (month and wind direction dependent; 1.0 for hours before sunrise or after sunset) (non-dimensional)
16-18	wind speed, wind direction, and anemometer height that were used in the computations in Stage 3 (m s^{-1}, degrees, m)
19-20	temperature and measurement height that were used in the computations in Stage 3 (K and m).

The format of this file is in Appendix C. The theoretical bases for the calculations that estimate the boundary layer parameters are in Section 5.

Notice that for March 2, 1988, hours 2-7, the boundary layer parameters are represented by missing value indicators (the various '-9' fields). Examining either the message file or the second page of the summary report, note that the winds were calm for these time periods. The wind speed and direction (fields 16 and 17) are set to 0.0 indicating a calm wind.

The last five fields are 'reference' data that AERMET used in its calculations and AERMOD uses in some of its calculations. In the absence of site-specific data, as in this example, AERMET substitutes the NWS data. Note that the anemometer height (field 18) is the height specified with the NWS_HGT keyword. In Section 3, we will see how the introduction of site-specific data affects the output in this file.

Figure 2-18 shows the first 36 hours from the profile file. The contents of this file are:

field(s)	description
1-4	year (2-digit), month, day, and hour
5	measurement height (m)
6	indicator flag: 1=last level in profile for the hour, 0=not the last level
7-8	wind direction and speed (m s^{-1}, m)
9	temperature (°C)
10	σ_A - standard deviation of the lateral wind direction (degrees)
11	σ_w - standard deviation of the vertical wind speed (m s^{-1})

The format of this file is in Appendix C. None of the parameters in this file are computed; the only changes that may occur are conversion of the units.

For this example there is one record per hour of meteorological output data. Since there are no site-specific data in this example, AERMET constructed a one-level profile by substituting NWS data. These data match the last fields in the boundary layer parameter file, except that the temperature is expressed in different units. Since the NWS does not report the fluctuating components of the wind (the σ's), these fields are filled with the missing value indicators. In Section 3, we will see how the introduction of site-specific data affects the output in this file.

```
     AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                               Version  98314

                  Data Processed on 11-NOV-98 at 11:45:58

            ********************************************************
            ***        AERMET Setup Finished Successfully        ***
            ********************************************************

  1.  Input/Output Files

      STAGE3-1.RPT                                         OPENED SUCCESSFULLY
      STAGE3-1.MSG                                         OPENED SUCCESSFULLY
      MERGE.DSK                                            OPENED SUCCESSFULLY
      AERMET.SFC                                           OPENED SUCCESSFULLY
      AERMET.PFL                                           OPENED SUCCESSFULLY

  2.  Dispersion Model for which Data Are Processed

        AERMOD

  3.  Processing Options

         Process       Scheme        Description
         -------       ------        -----------
      WIND DIRECTION   RANDOM    NWS wind directions are RANDOMIZED
      REFERENCE LEVEL  SUBNWS    NWS data ARE SUBSTITUTED for on-site   data

  4.  Locations of Meteorological Data

       Data           Site     Longitude   Latitude
      Pathway          ID      (degrees)   (degrees)
      -------         ----     ---------   ---------
      UPPERAIR     00014735      73.80W      42.75N
      SURFACE         14735       73.8W      42.75N
      ONSITE              0

      ****************************************
      * Longitude and Latitude for Processing *
      *         74.00      41.30             *
      ****************************************

  5.  Surface Characteristics

                Wind Sector                Bowen   Roughness
        Month   Start   End    Albedo      Ratio   Length (m)
        --------------------------------------------------
          1        0.  360.    0.1500    2.0000     0.1200
          2        0.  360.    0.1500    2.0000     0.1200
          3        0.  360.    0.1500    2.0000     0.1200
          4        0.  360.    0.1500    2.0000     0.1200
          5        0.  360.    0.1500    2.0000     0.1200
          6        0.  360.    0.1500    2.0000     0.1200
          7        0.  360.    0.1500    2.0000     0.1200
          8        0.  360.    0.1500    2.0000     0.1200
          9        0.  360.    0.1500    2.0000     0.1200
         10        0.  360.    0.1500    2.0000     0.1200
         11        0.  360.    0.1500    2.0000     0.1200
         12        0.  360.    0.1500    2.0000     0.1200

  6.  Input File(s) for   AERMOD

        Surface Meteorology:  AERMET.SFC
        Profile Data       :  AERMET.PFL
```

FIGURE 2-16a. FIRST PART OF THE SUMMARY FILE FROM STAGE3.

```
         AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                  Version  98314

                      Data Processed on 11-NOV-98 at 11:45:58

                ********************************************************
                ***   AERMET Data Processing Finished Successfully   ***
                ********************************************************

                 PROCESSING METEOROLOGICAL DATA FOR DISPERSION MODELING


                      **** AERMET MESSAGE SUMMARY TABLE ****

             Ø- 9   1Ø-19   2Ø-29   3Ø-39   4Ø-49   5Ø-59   6Ø-69   7Ø-89   TOTAL
           ----------------------------------------------------------------------

      METPREP
        E    Ø       Ø       Ø       Ø       Ø       Ø       Ø       Ø       Ø
        W    Ø       Ø       Ø       Ø       Ø       Ø       Ø       8       8
        I    Ø       1       Ø       Ø       Ø       Ø       Ø       1       2
        T    Ø       Ø       Ø       Ø       Ø       Ø       Ø       Ø       Ø
           ----------------------------------------------------------------------
             Ø       1       Ø       Ø       Ø       Ø       Ø       9      1Ø

          ****    ERROR MESSAGES  ****

                 ---  NONE  ---


          ****   WARNING MESSAGES ****
    88Ø3Ø2 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: Ø2
    88Ø3Ø2 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: Ø3
    88Ø3Ø2 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: Ø4
    88Ø3Ø2 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: Ø5
    88Ø3Ø2 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: Ø6
    88Ø3Ø2 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: Ø7
    88Ø3Ø3 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 19
    88Ø3Ø3 METPREP    W71  MPPBL: CALM WIND: NO BDRY LYR PARAMETERS FOR HR: 21
```

FIGURE 2-16b. SECOND PART OF THE SUMMARY FILE FROM STAGE3.

```
     41.3N     74.00W          UA_ID: 00014735  SF_ID:    14735  OS_ID:         0     VERSION: 98314
 88  3  1  61  1  -30.6  0.285 -9.000 -9.000 -999.  350.     67.5  0.120   2.00   1.00    3.10  275.    6.1  270.4    2.0
 88  3  1  61  2  -45.7  0.393 -9.000 -9.000 -999.  567.    119.1  0.120   2.00   1.00    4.10  279.    6.1  270.4    2.0
 88  3  1  61  3  -45.9  0.393 -9.000 -9.000 -999.  567.    118.5  0.120   2.00   1.00    4.10  279.    6.1  269.3    2.0
 88  3  1  61  4  -58.6  0.500 -9.000 -9.000 -999.  813.    191.0  0.120   2.00   1.00    5.10  290.    6.1  268.1    2.0
 88  3  1  61  5  -64.0  0.564 -9.000 -9.000 -999.  973.    250.6  0.120   2.00   1.00    5.70  290.    6.1  267.5    2.0
 88  3  1  61  6  -26.1  0.221 -9.000 -9.000 -999.  382.     37.1  0.120   2.00   1.00    2.60  295.    6.1  267.5    2.0
 88  3  1  61  7  -59.2  0.500 -9.000 -9.000 -999.  813.    189.1  0.120   2.00   1.00    5.10  286.    6.1  267.0    2.0
 88  3  1  61  8  -38.6  0.398 -9.000 -9.000 -999.  584.    146.1  0.120   2.00   0.53    4.10  315.    6.1  267.5    2.0
 88  3  1  61  9   63.5  0.741  0.879  0.005  384. 1466.   -573.4  0.120   2.00   0.28    7.20  273.    6.1  268.1    2.0
 88  3  1  61 10  134.7  0.847  1.365  0.005  678. 1787.   -403.9  0.120   2.00   0.20    8.20  297.    6.1  268.1    2.0
 88  3  1  61 11  198.0  0.802  1.606  0.005  752. 1659.   -234.0  0.120   2.00   0.17    7.70  297.    6.1  268.8    2.0
 88  3  1  61 12  220.1  0.912  1.749  0.005  871. 1998.   -308.9  0.120   2.00   0.16    8.80  268.    6.1  268.8    2.0
 88  3  1  61 13  224.2  0.962  1.853  0.005 1017. 2165.   -355.3  0.120   2.00   0.16    9.30  271.    6.1  269.3    2.0
 88  3  1  61 14  204.9  0.754  1.857  0.005 1119. 1560.   -187.1  0.120   2.00   0.16    7.20  306.    6.1  269.3    2.0
 88  3  1  61 15  163.3  0.958  1.759  0.005 1194. 2150.   -481.6  0.120   2.00   0.17    9.30  256.    6.1  268.8    2.0
 88  3  1  61 16  101.7  0.745  1.523  0.005 1242. 1533.   -362.4  0.120   2.00   0.19    7.20  268.    6.1  268.8    2.0
 88  3  1  61 17   25.3  0.898  0.960  0.005 1251. 1951.   -998.0  0.120   2.00   0.25    8.80  270.    6.1  267.5    2.0
 88  3  1  61 18  -64.0  0.889 -9.000 -9.000 -999. 1930.    981.2  0.120   2.00   0.43    8.80  266.    6.1  265.9    2.0
 88  3  1  61 19  -64.0  0.889 -9.000 -9.000 -999. 1929.    981.2  0.120   2.00   1.00    8.80  273.    6.1  265.4    2.0
 88  3  1  61 20  -64.0  0.671 -9.000 -9.000 -999. 1317.    420.9  0.120   2.00   1.00    6.70  278.    6.1  264.3    2.0
 88  3  1  61 21  -64.0  0.671 -9.000 -9.000 -999. 1264.    420.5  0.120   2.00   1.00    6.70  285.    6.1  263.8    2.0
 88  3  1  61 22  -53.5  0.446 -9.000 -9.000 -999.  732.    148.6  0.120   2.00   1.00    4.60  294.    6.1  263.1    2.0
 88  3  1  61 23  -33.7  0.281 -9.000 -9.000 -999.  367.     58.6  0.120   2.00   1.00    3.10  220.    6.1  262.5    2.0
 88  3  1  61 24  -26.5  0.220 -9.000 -9.000 -999.  239.     35.8  0.120   2.00   1.00    2.60  209.    6.1  261.4    2.0
 88  3  2  62  1   -7.1  0.076 -9.000 -9.000 -999.   68.      5.6  0.120   2.00   1.00    1.50  289.    6.1  260.4    2.0
 88  3  2  62  2 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.120   2.00   0.15    0.00    0.    6.1  259.3    2.0
 88  3  2  62  3 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.120   2.00   0.15    0.00    0.    6.1  258.8    2.0
 88  3  2  62  4 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.120   2.00   0.15    0.00    0.    6.1  258.1    2.0
 88  3  2  62  5 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.120   2.00   0.15    0.00    0.    6.1  258.8    2.0
 88  3  2  62  6 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.120   2.00   0.15    0.00    0.    6.1  257.5    2.0
 88  3  2  62  7 -999.0 -9.000 -9.000 -9.000 -999. -999. -99999.0  0.120   2.00   0.15    0.00    0.    6.1  257.5    2.0
 88  3  2  62  8  -17.6  0.147 -9.000 -9.000 -999.  129.     16.0  0.120   2.00   0.52    2.10  118.    6.1  262.0    2.0
 88  3  2  62  9   70.2  0.437  0.772  0.020  233.  665.   -106.2  0.120   2.00   0.28    4.10  163.    6.1  264.3    2.0
 88  3  2  62 10  145.7  0.651  1.116  0.009  340. 1208.   -169.0  0.120   2.00   0.20    6.20  174.    6.1  265.9    2.0
 88  3  2  62 11  193.4  0.505  1.366  0.012  471.  844.    -59.3  0.120   2.00   0.17    4.60  147.    6.1  267.0    2.0
 88  3  2  62 12  225.7  0.508  1.526  0.013  562.  834.    -51.9  0.120   2.00   0.16    4.60  165.    6.1  269.3    2.0
```

FIGURE 2-17. FIRST 36 HOURS OF THE BOUNDARY LAYER PARAMETER FILE, AERMET.SFC.

88	3	1	1	6.1	1	275.	3.10	-2.8	99.0	99.00
88	3	1	2	6.1	1	279.	4.10	-2.8	99.0	99.00
88	3	1	3	6.1	1	279.	4.10	-3.9	99.0	99.00
88	3	1	4	6.1	1	290.	5.10	-5.0	99.0	99.00
88	3	1	5	6.1	1	290.	5.70	-5.6	99.0	99.00
88	3	1	6	6.1	1	295.	2.60	-5.6	99.0	99.00
88	3	1	7	6.1	1	286.	5.10	-6.1	99.0	99.00
88	3	1	8	6.1	1	315.	4.10	-5.6	99.0	99.00
88	3	1	9	6.1	1	273.	7.20	-5.0	99.0	99.00
88	3	1	10	6.1	1	297.	8.20	-5.0	99.0	99.00
88	3	1	11	6.1	1	297.	7.70	-4.4	99.0	99.00
88	3	1	12	6.1	1	268.	8.80	-4.4	99.0	99.00
88	3	1	13	6.1	1	271.	9.30	-3.9	99.0	99.00
88	3	1	14	6.1	1	306.	7.20	-3.9	99.0	99.00
88	3	1	15	6.1	1	256.	9.30	-4.4	99.0	99.00
88	3	1	16	6.1	1	268.	7.20	-4.4	99.0	99.00
88	3	1	17	6.1	1	270.	8.80	-5.6	99.0	99.00
88	3	1	18	6.1	1	266.	8.80	-7.2	99.0	99.00
88	3	1	19	6.1	1	273.	8.80	-7.8	99.0	99.00
88	3	1	20	6.1	1	278.	6.70	-8.9	99.0	99.00
88	3	1	21	6.1	1	285.	6.70	-9.4	99.0	99.00
88	3	1	22	6.1	1	294.	4.60	-10.0	99.0	99.00
88	3	1	23	6.1	1	220.	3.10	-10.6	99.0	99.00
88	3	1	24	6.1	1	209.	2.60	-11.7	99.0	99.00
88	3	2	1	6.1	1	289.	1.50	-12.8	99.0	99.00
88	3	2	2	6.1	1	0.	0.00	-13.9	99.0	99.00
88	3	2	3	6.1	1	0.	0.00	-14.4	99.0	99.00
88	3	2	4	6.1	1	0.	0.00	-15.0	99.0	99.00
88	3	2	5	6.1	1	0.	0.00	-14.4	99.0	99.00
88	3	2	6	6.1	1	0.	0.00	-15.6	99.0	99.00
88	3	2	7	6.1	1	0.	0.00	-15.6	99.0	99.00
88	3	2	8	6.1	1	118.	2.10	-11.1	99.0	99.00
88	3	2	9	6.1	1	163.	4.10	-8.9	99.0	99.00
88	3	2	10	6.1	1	174.	6.20	-7.2	99.0	99.00
88	3	2	11	6.1	1	147.	4.60	-6.1	99.0	99.00
88	3	2	12	6.1	1	165.	4.60	-3.9	99.0	99.00

FIGURE 2-18. FIRST 36 HOURS OF THE PROFILE FILE, AERMET.PFL.

SECTION 3

ADVANCED TUTORIAL

In the example in Section 2, only NWS data were used to estimate the boundary layer parameters for AERMOD. In this section, a second example is presented that introduces data from an site-specific meteorological observation program into the data processing. This example builds on the data that were processed in Section 2 - the hourly surface observations and upper air soundings - without modification. The keywords associated with the ONSITE pathway for Stage 1 and the modifications to the runstreams for Stage 2 and Stage 3 necessary to generate the input data files for the AERMOD dispersion model using both the NWS and site-specific data are presented. At the end of this section, a short discussion on combining and separating processing steps in Stage 1 is presented.

3.1 EXAMPLE 2: Site-specific DATA

Unlike NWS data where the data are in predefined formats and the processing is reasonably straightforward, site-specific data do not come in a 'prepackaged' archive format and the user must know the structure of the data, including how missing values are reported. Processing the data becomes more complicated. Several exercises will be suggested, requiring minimal modifications to the runstreams provided with this example, so the user can see the consequence of including or excluding keywords.

The example leads the user through the steps necessary to generate the input data files for AERMOD using both NWS and site-specific meteorological data. Before reading the discussion of the keywords and output for this example, we recommend running AERMET to generate the output files - the message files, the summary reports, and the meteorological data output. For this example, it is assumed that the hourly surface and upper air data were extracted and QA'd in the first example. Then the three steps and associated runstream file names, which are provided on diskette accompanying this User's Guide, to generate the meteorological data for AERMOD are:

- QA site-specific data (Stage 1): EX2-OS.INP
- combine the surface, upper air and site-specific data into one file (Stage 2): EX2-MRG.INP
- process the combined data to produce the meteorological output for AERMOD (Stage 3): EX2-ST3.INP.

The discussion in Section 2.2 about DOS redirection applies to this example as well. The syntax for redirecting the standard input from a file is:

executable_program_name

The file name that instructs AERMET to read and process the information is called:
executable_program_name.INP

The following table shows what to type at the DOS prompt for each step in this example. These steps must be run in the order shown.

To:	At the DOS prompt, type:	Meteorological input data file(s)	Output data file(s)
QA site-specific data	COPY EX2-OS.INP STAGE1N2.INP STAGE1N2 <	ONSITE.MET	OSQAOUT.DSK
Combine data	COPY EX2-MRG.INP STAGE1N2.INP STAGE1N2	SFQAOUT.DSK* UAQAOUT.DSK* OSQAOUT.DSK	MERGE2.DSK
Create meteorological files for AERMOD	COPY EX2-ST3.INP STAGE3.INP STAGE3	MERGE2.DSK	AERMET2.SFC AERMET2.PFL

* - these files were generated in the first example.

As AERMET runs, the progress is displayed on the screen. The display is described below, after the discussion of the keywords. In addition to the output data files, each run will produce a message file (with a .MSG extension) and report file (.RPT) file. Note: the file names and extensions are all user-defined; i.e., there are no default names or extensions.

A reminder: all output files are opened with the Fortran file OPEN specifier of STATUS = 'UNKNOWN'. With this specifier, if the file already exists, the contents will be overwritten without any opportunity to save it.

3.1.1 Stage 1 - Processing Site-specific Data

Site-specific data are assumed to be from one or more levels of an instrumented tower, a remote sensor (e.g. sodar), or a combination of the two, and possibly with additional near-surface data, such as insolation and net radiation. The site-specific data that will be processed in this example come from a 100-meter meteorological tower with three levels of data - 10, 50, and 100 meters - with winds, temperature and the fluctuating components of the wind. Four new keywords are added with this example.

There is no standard archive format or content for site-specific data and, as such, places the format of the data completely under the control of the user. Therefore, since there is no archive file, there is no extraction step and the data can be QA'd immediately, as shown in Figure 3-1.

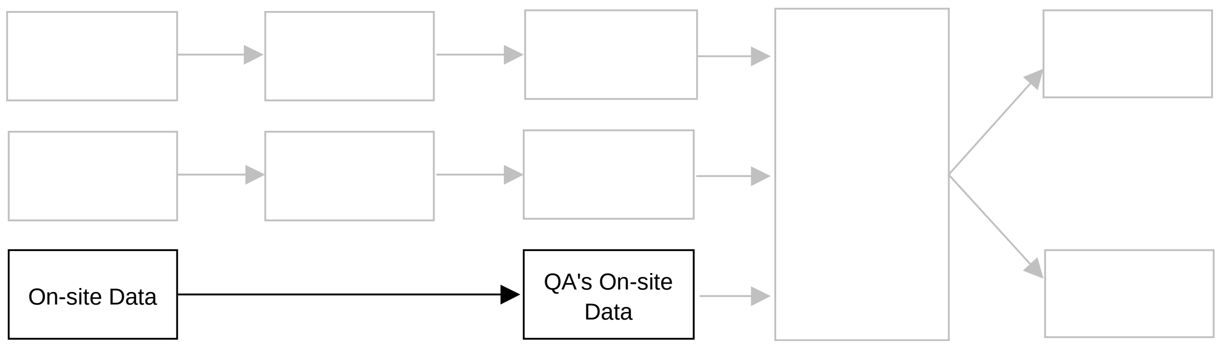

FIGURE 3-1. STAGE 1 PROCESSING OF THE Site-specific DATA.

Without a standard format or content, the user must describe the file for AERMET. The format of the site-specific data is reasonably flexible, subject to the following rules:

1) The data for one observation period can be one or more data records, and the records for the period must be contiguous (for this tutorial, refer to this as an "observation group");

2) There can be up to 12 equally-spaced observation periods per hour, i.e., as frequent as every 5 minutes (see the keyword OBS/HOUR in Section 4 for a discussion on how to provide AERMET with the frequency of site-specific observations);

3) The same set of variables must appear for all observation periods but not all the same variables must appear on every record in the observation period;

4) The date and time information for each observation must be contained in the first record of the group; these may occur in any order within the first record, and must be integer format; site-specific meteorological variables can appear on the first record;

5) The variables present within each observation should be a subset of those listed in Appendix B, Tables B-3a and B-3b (although the user can direct AERMET to skip fields);

6) Single-level variables (e.g., heat flux and observed mixing heights) must be read before any multi-level variables (e.g., winds and temperature); these two types of variables are described below;

7) The file must be ASCII and it must be in a form that can be read using Fortran FORMAT statements. AERMET does not support free format read (i.e., using the asterisk to define the format) at this time.

Figure 3-2 shows a subset of the data for this example. There are three records for each observation group and the data are reported once per hour. The structure and fields are explained below under the "READ and FORMAT" heading. The connection between the rules and the data should become clearer when the keywords used to read the data are discussed.

```
 1  3 88  1  0   10.0  48.7   0.110   0.64  317.50    0.80
 1  3 88  1  0   50.0  14.7  99.000   1.84  323.30    2.00
 1  3 88  1  0  100.0   9.1   0.410   1.64  320.50    3.70
 1  3 88  2  0   10.0  22.5   0.080   0.34  273.10    0.90
 1  3 88  2  0   50.0  15.6  99.000   1.04  304.00    1.50
 1  3 88  2  0  100.0  13.4   0.340   0.74  308.50    2.50
 1  3 88  3  0   10.0  63.3   0.080  -0.76  276.50    0.60
 1  3 88  3  0   50.0  32.9  99.000   0.04  331.70    1.30
 1  3 88  3  0  100.0  27.0   0.390  -0.16  319.10    2.30
```

FIGURE 3-2. SUBSET OF Site-specific METEOROLOGICAL DATA FOR EXAMPLE 2.

Figure 3-3 shows the runstream that will be used to QA the site-specific data in this example, and is provided in the file EX2-OS.INP. Several keywords for the ONSITE pathway are identical to those on the SURFACE and UPPERAIR pathways. The basic requirements to process the site-specific data are described below.

```
JOB                                                      Start of the JOB pathway

  MESSAGES ONSITE.MSG                                    Message file

  REPORT   ONSITE.RPT                                    Summary report file


ONSITE                                                   Start of the ONSITE pathway

  DATA      ONSITE.MET                                         Input file with site-
                                                               specific meteorological
                                                               data

  XDATES    88/3/1 TO 88/3/1Ø                            Period of observations to QA

  LOCATION  99999  74.ØW 41.3N  Ø                              Site identifier and
                                                              location

  QAOUT     OSQAOUT.DSK                                        Output file

  READ 1 OSDY OSMO OSYR OSHR HTØ1 SAØ1 SWØ1 TTØ1 WDØ1 WSØ1       Variables to read: 1st
                                                               record of the observation

  READ 2                 HTØ2 SAØ2 SWØ2 TTØ2 WDØ2 WSØ2         Variables to read: 2nd
                                                              record

  READ 3                 HTØ3 SAØ3 SWØ3 TTØ3 WDØ3 WSØ3         Variables to read: 3rd
                                                              record

  FORMAT 1 (4(I2,1X),4X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)      Format: 1st
                                                                       record of the
                                                                       observation

  FORMAT 2 (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)             Format: 2nd
                                                                       record

  FORMAT 3 (16X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)             Format: 3rd
                                                                       record

  RANGE TT -3Ø < 4Ø -99                                        Redefine QA parameters
                                                               for temperature

  RANGE SA Ø <= 95  -99                                        Redefine QA parameters
                                                                for σA

  RANGE WS Ø < 5Ø   -999                                       Redefine QA parameters
                                                               for wind speed

  RANGE WD Ø <= 36Ø -999                                       Redefine QA parameters
                                                               for wind dir'n

  THRESHOLD  Ø.3                                               Minimum wind speed below
                                                               which site-specific winds
                                                               are treated as calm
```

FIGURE 3-3. RUNSTREAM TO QA Site-specific TOWER DATA.

3.1.1.1 JOB pathway

The JOB pathway keywords are identical to what was presented for the first example. The messages are written to the file ONSITE.MSG and the summary report is written to the file ONSITE.RPT.

3.1.1.2 ONSITE pathway

The ONSITE statement indicates that a block of keyword statements for the ONSITE pathway are to follow. The basic keywords to QA the site-specific data in this example are:

DATA -	specifies the input file name of the raw data;
XDATES -	specifies the period of time to be retrieved and QA'd from the data file;
LOCATION -	specifies the station identifier, latitude and longitude and the value to convert time to local standard time;
QAOUT -	specifies the output file name from the QA process; this keyword is also used to specify the input file name to Stage 2;
READ -	defines the order of the variables as they appear in the DATA file; this keyword is repeatable up to the number of records per observations period;
FORMAT -	defines the format of the variables as they appear in the DATA file; this keyword is repeatable;
THRESHOLD -	defines the lowest allowable wind speed in the site-specific data; any wind speeds that are less than this value are treated as calm;
RANGE -	modifies the default upper and lower QA bounds as well as the missing value indicator for the meteorological variable specified.

All of these keywords except the last one are mandatory. The order of these keywords within the ONSITE pathway is not important. Notice that there is no EXTRACT keyword since the data are QA'd directly from the raw data file.

DATA, LOCATION, XDATES, and QAOUT

The site-specific data are stored in a file called ONSITE.MET as shown with the DATA keyword. A file format is not required with this keyword on the ONSITE pathway because there is no standard archive format associated with site-specific data. A blocking factor of one is assumed. The definition of the format will be provided by the user through the READ and FORMAT keywords described below.

The XDATES, LOCATION and QAOUT keywords for the ONSITE pathway are identical in content and purpose to the same keywords for the SURFACE and UPPERAIR pathways. The only difference of note is that the site identifier for the LOCATION keyword can be any integer descriptor, with a maximum length of eight characters, since the content of this field is not checked in AERMET. However, this identifier is written to one of the AERMET output files and is, in turn, checked by AERMOD. Since AERMOD reads the field as integer, the user should specify the site identifier as an integer to avoid an error in AERMOD. In this example, the site identifier is 99999.

READ and FORMAT

The READ and FORMAT keywords, rather than a predefined format, are the keys to reading the site-specific data. There are some rules to follow in using these two keywords:

1) For every READ keyword there <u>must</u> be a corresponding FORMAT keyword in the runstream;

2) The two keywords are linked through an index immediately following the keyword to identify which data record in the observation group is being referenced.

3) Blanks in the format specification must be avoided because AERMET recognizes blanks as field delimiters on keywords.

4) The list-directed format (specified by an asterisk, *) cannot be used to direct AERMET to read the data.

The READ keyword defines the variables present on each data record in the order they are to be read from the input file. The first parameter after the READ keyword is the index indicating the data record in the observation group the READ keyword references. The list of variables to be read follows the index.

There are two types of site-specific meteorological variables that are recognized by AERMET: single-level and multi-level. The single-level measurements are usually observed near the earth's surface. Examples of single-level variables are net radiation and sensible heat flux. Site-specific observations of mixing heights are also included in the list of single-level measurements even though they may not be near-surface for a highly convective atmosphere. The multi-level variables can be reported at multiple heights and can come from an instrumented meteorological tower, a remote sensor (e.g., sodar or lidar), or any other meteorological instrumentation that can report data at several levels in the atmosphere (e.g., tethered balloon). Examples of multi-level variables are temperature and wind speed. Each variable is identified by a 4-character name; the allowable names are listed in Appendix C. The complete name of multi-level variables depends on the level at which they are observed. The first two characters identify the meteorological variable and the last two characters are numeric and identify the level from which the data are reported. The naming convention for multi-level variable is described in more detail in Section 4.5.2.

The format of the variables on each data record is specified on a corresponding FORMAT keyword. This keyword contains the index indicating which record in the observation group the keyword references followed by the Fortran format string, enclosed in parentheses, that is used to read the data. The format must comply with all the rules of syntax for constructing a FORMAT statement and the parentheses are mandatory. Refer to any introductory text on Fortran programming or compiler manual for the Fortran syntax rules. There can be a maximum 20 of data records per observation period and a maximum of 20 variables on any one data record. Remember, however, that the maximum length of a runstream record is limited to 80 characters.

Not all of the variables present in the site-specific data file need to be read. Any superfluous data can easily be skipped over using the X, T and / edit descriptors. However,

☞ **the same format used to read the original site-specific data file is also used to write the QA file**.

If some variables are skipped (using the X and T descriptors) or entire lines of data are skipped (using the "/"), then the QA output file will contain corresponding blank fields and/or blank lines.

Referring to Figure 3-2, three records corresponding to the three measurement levels define the site-specific data for a single observation period. The observation period in this example is one hour (site-specific data may contain more than one observation period per hour; see Section 4.5.12 for a discussion of the keyword OBS/HOUR). The first data record contains the day, month, year, hour, and minute of the observation. These fields are followed by the observation height (meters), σ_A (degrees), σ_w (meters/second), ambient air temperature (°C), wind direction (degrees), and wind speed (meters/second). The second and third records contain the same information. This structure is repeated for all hours of the data set. It is only coincidental that the same variables are repeated for each measurement height. It is entirely possible, and a situation that AERMET can handle, that different variables are measured at different levels.

In this example, 10 variables are present read on the first record of the observation group in Figure 3-2. In the runstream, the variables corresponding to these data are defined on the READ keyword followed by the index 1. The first four variables are the day, month, year, and hour and are read into the integer variables OSDY, OSMO, OSYR, and OSHR, respectively (see Tables B-3a and B-3b for the list of valid variable names). The next six variables are σ_A, σ_w, temperature, wind direction, and wind speed - all at the first level. These data are read into SA01, SW01, TT01, WD01, and WS01. These variable names consist of a 2-letter prefix and a 2-digit suffix. The prefix identifies the variable, as defined in Table B-3b, and the suffix identifies the measurement level. This record is read with the format defined on the FORMAT keyword that is followed by the index 1.

The second and third records of the observation period are read in a similar manner. Note, however, that the second and third data records also contain the date and time data, but that information is skipped by AERMET - no date variables are specified and the FORMAT utilized '16X' to skip the first 16 columns in the data file.

With these six statements in the runstream, the site-specific data format is completely specified. If, for any reason, the data structure changes within the file, then AERMET will stop processing data and identify where the problem was encountered.

THRESHOLD

Anemometers measuring the wind speed may not detect air movement below certain speeds, or thresholds. These thresholds are instrument-dependent. While it is hoped that winds reported in the raw data base have already accounted for this minimum, it is possible that speeds less than the threshold for the instrument appear in the data. The keyword THRESHOLD is used to define the threshold wind speed and directs AERMET to treat any site-specific wind speeds that are below this threshold as calm winds. This is a mandatory keyword - AERMET will not process the site-specific data without it. In this example, the threshold wind speed is 0.3 meters/second.

RANGE

An optional, but very useful, keyword is the RANGE keyword. This keyword can be used on the SURFACE and UPPERAIR pathways, but is most useful on the ONSITE pathway where indicators of missing values (e.g., -999.0) are data base dependent. AERMET has default upper and lower bounds for the QA and missing value indicator for each variable (see Tables B-3a and B-3b). The RANGE keyword allows the user to change one or all of these values for a variable. If AERMET is not made aware of the correct missing value indicator(s), then it will assume the default indicator identifies the missing data and AERMET may use invalid data in a calculation. This situation could lead to an abrupt termination of the program, such as attempting to compute the square root of a negative number, without any indications in the message and summary file as to what happened.

One RANGE keyword is required for each variable's QA parameters that the user wants to modify.   The parameters associated with the RANGE keyword are:

1) variable name - for multi-level variables such as temperature and wind speed, only the first two characters are needed - the changes apply to all measurement levels;

2) lower bound;

3) symbol indicating whether the range of valid values should include (<=) or exclude (<) the endpoints (bounds);

4) upper bound;

5) missing value indicator.

Any or all of items 2 through 5 can be changed, but each of these parameters must appear with the RANGE keyword. If, for example, the missing value indicator needs to be modified but the bounds can remain the same, the default bounds for the variable defined in Tables B-3a and B-3b should be used with the new missing indicator specified. This situation is exactly why this keyword had to be included in this example. Several of the QA bounds also were changed. Compare the parameters on the RANGE keywords to the values in Tables B-3b and then examine the data for March 1, 1988, hour 11 in the file ONSITE.MET.

There are two optional keywords available for the ONSITE pathway that perform the same function as on the SURFACE and UPPERAIR pathways. These are:

AUDIT - adds variables to the list of variables to be tracked and reported during QA;

NO_MISSING - suppresses the message that data are missing for variables being audited during the QA process; this keyword is useful in reducing the size of the message file if an audited variable is missing most of the time.

There are several new, optional keywords for the ONSITE pathway:

DELTA_TEMP - defines the height(s), in meters, for temperature difference data, if it exists in the data base;

OSHEIGHTS - defines the heights of the site-specific measurements; this keyword is needed if the heights are not included on each of the multi-level data records or not on the READ keywords;

OBS/HOUR - number of observation periods per hour; required only if the number of periods exceeds 1/hour;

All the keywords are discussed in detail in Section 4, and a synopsis of each is provided in Appendix A.

3.1.2 Running Stage 1 and Reviewing the Output

To run Stage 1 to QA the site-specific meteorological data, the following command lines are used:

```
COPY EX2-OS.INP STAGE1N2.INP
STAGE1N2
```

where EX2-OS.INP is the example runstream file name.

Figure 3-4 shows a portion of the messages that result from running EX2-OS.INP. All the QA messages were the same, so the middle section was omitted. The 'standard' end of file and processing that was not performed precede the QA messages. These messages show how the QA violations of the multi-level data are reported.

```
        JOB        I19  SETUP: "END OF FILE" ON UNIT  5 AFTER RECORD #  24
        JOB        I25   TEST: SUMMARY: NO DATA EXTRACTION FOR UPPERAIR
        JOB        I25   TEST: SUMMARY: NO DATA QA FOR UPPERAIR
        JOB        I26   TEST: SUMMARY: NO DATA EXTRACTION FOR SURFACE
        JOB        I26   TEST: SUMMARY: NO DATA QA FOR SURFACE
 880301 ONSITE     Q59 OSQACK: TT   MISSING FOR HR 11, LEVEL: 1
 880301 ONSITE     Q59 OSQACK: TT   MISSING FOR HR 11, LEVEL: 2
 880301 ONSITE     Q59 OSQACK: TT   MISSING FOR HR 11, LEVEL: 3
 880301 ONSITE     Q59 OSQACK: WD   MISSING FOR HR 11, LEVEL: 1
 880301 ONSITE     Q59 OSQACK: WD   MISSING FOR HR 11, LEVEL: 2
 880301 ONSITE     Q59 OSQACK: WD   MISSING FOR HR 11, LEVEL: 3
 880301 ONSITE     Q59 OSQACK: WS   MISSING FOR HR 11, LEVEL: 1
 880301 ONSITE     Q59 OSQACK: WS   MISSING FOR HR 11, LEVEL: 2
 880301 ONSITE     Q59 OSQACK: WS   MISSING FOR HR 11, LEVEL: 3
   .      .           .                   .
   .      .           .                   .
   .      .           .                   .
 880308 ONSITE     Q59 OSQACK: TT   MISSING FOR HR 10, LEVEL: 1
 880308 ONSITE     Q59 OSQACK: TT   MISSING FOR HR 10, LEVEL: 2
 880308 ONSITE     Q59 OSQACK: TT   MISSING FOR HR 10, LEVEL: 3
 880308 ONSITE     Q59 OSQACK: WD   MISSING FOR HR 10, LEVEL: 1
 880308 ONSITE     Q59 OSQACK: WD   MISSING FOR HR 10, LEVEL: 2
 880308 ONSITE     Q59 OSQACK: WD   MISSING FOR HR 10, LEVEL: 3
 880308 ONSITE     Q59 OSQACK: WS   MISSING FOR HR 10, LEVEL: 1
 880308 ONSITE     Q59 OSQACK: WS   MISSING FOR HR 10, LEVEL: 2
 880308 ONSITE     Q59 OSQACK: WS   MISSING FOR HR 10, LEVEL: 3
```

FIGURE 3-4. PORTION OF THE MESSAGE FILE FROM Site-specific DATA QA.

The QA messages contain the following information:

Field 1: the observation date
Field 2: the pathway
Field 3: the message code
Field 4: the subroutine that issued the message
Field 5: the message

- the variable in question: TT = temperature, WD = wind direction, and WS = wind speed
- the problem: data are missing for the hour with the level indicated.

Figures 3-5a through 3-5d show the summary report associated with running EX2-OS.INP. The first two pages are similar to the first pages for the SURFACE and UPPERAIR processing except that only the site-specific data section contains processing information. Note that on the message summary table (Figure 3-5b) there were 61 QA messages in the 50-59 range. Examining the message file, we see that all the missing data messages had the message code 'Q59', which were categorized into the 50-59 range.

The third page of the summary report (Figure 3-5c) shows some of the important parameters that will also be used in the processing including the threshold wind speed. The 'Heights for multi-level data' shows the heights at which the site-specific data measurements were observed, but only if the OSHEIGHTS keyword was used. Otherwise, the heights are shown as 0.0.

The fourth page (Figure 3-5d) shows the QA summary table. Only temperature, wind speed, and wind direction are automatically QA'd, which are multi-level variables. No additional variables were specified with the AUDIT keyword for QA. The summary is reported by level and by variable within the level. Recall that 10 days were processed for a total of 240 hours. The "% accepted" exceeds 98% for all variables, except for temperature at the 50-meter level. The 41 reported missing values may cause the user to check the data to insure the data are really missing. Unlike the QA for hourly surface and upper air data, the "Test Values" at the right of the table are not multiplied by any factors.

Once the user is satisfied that there is nothing unusual in the data, the ONSITE data are ready to merge with the data from the SURFACE and UPPERAIR pathways.

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                   Version  98314

                      Data Processed on 11-NOV-98 at 15:26:28

              ********************************************************
              ***        AERMET Setup Finished Successfully        ***
              ********************************************************

   1.  Job File Names

       Listing of Messages: ONSITE.MSG
       Summary (this file): ONSITE.RPT


   2.  Upper Air Data

       AERMET Has Determined That Processing For This Pathway Includes:
            NONE, NO DATA TO BE PROCESSED ON THIS PATH



   3.  NWS Surface Data

       AERMET Has Determined That Processing For This Pathway Includes:
            NONE, NO DATA TO BE PROCESSED ON THIS PATH



   4.  On-site Data

        Site ID    Latitude(deg.)   Longitude(deg.)   Conversion to LST
       99999          41.3N             74.0W               0

       AERMET Has Determined That Processing For This Pathway Includes:
            QUALITY ASSESSMENT ONLY

            Extract Output-    OPEN: ONSITE.MET
            QA Output     -    OPEN: OSQAOUT.DSK

            The Extract Dates Are:    Starting:  1-MAR-88
                                        Ending: 10-MAR-88
```

FIGURE 3-5a. FIRST PAGE OF THE SUMMARY FILE FOR THE Site-specific DATA QA.

```
AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                         Version  98314

              Data Processed on 11-NOV-98 at 15:26:29

       ********************************************************
       ***   AERMET Data Processing Finished Successfully   ***
       ********************************************************

             EXTRACT AND/OR QA THE METEOROLOGICAL DATA


               **** AERMET MESSAGE SUMMARY TABLE ****

       0- 9   10-19   20-29   30-39   40-49   50-59   60-69   70-89   TOTAL
      ---------------------------------------------------------------------

JOB
  E     0       0       0       0       0       0       0       0       0
  W     0       0       0       0       0       0       0       0       0
  I     0       1       4       0       0       0       0       0       5

ONSITE
  E     0       0       0       0       0       0       0       0       0
  W     0       0       0       0       0       0       0       0       0
  I     0       0       0       0       0       0       0       0       0
  Q     0       0       0       0       0      61       0       0      61
      ---------------------------------------------------------------------
        0       1       4       0       0      61       0       0      66

    ****    ERROR MESSAGES  ****

           ---  NONE  ---


    ****   WARNING MESSAGES ****

           ---  NONE  ---
```

FIGURE 3-5b. SECOND PAGE OF THE SUMMARY FILE FOR THE Site-specific DATA QA.3.

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                 Version  98314

                     Data Processed on 11-NOV-98 at 15:26:29

                   THE FOLLOWING ON-SITE VALUES ARE IN EFFECT

   Threshold wind speed (m/s):

      0.30


   Heights for multi-level data (m):

      0.00    0.00    0.00
```

FIGURE 3-5c. THIRD PAGE OF THE SUMMARY FILE FOR THE Site-specific DATA QA.

```
        AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                 Version  98314

                     Data Processed on 11-NOV-98 at 15:26:29

                ********************************************************
                ***   AERMET Data Processing Finished Successfully   ***
                ********************************************************


                       **** SUMMARY OF THE QA AUDIT ****
       THERE IS NO AUDIT TRAIL FOR SITE SCALARS


   SITE VECTORS          |------VIOLATION SUMMARY------|   |-----TEST VALUES-----|
               TOTAL     #     LOWER  UPPER     %       MISSING   LOWER   UPPER
               # OBS  MISSING  BOUND  BOUND  ACCEPTED     FLAG    BOUND   BOUND
       10.00 M
         TT     240        2      0      0     99.17      -99.0,  -30.0,   40.0
         WD     240        4      0      0     98.33     -999.0,    0.0,  360.0
         WS     240        4      0      0     98.33     -999.0,    0.0,   50.0
       50.00 M
         TT     240       41      0      0     82.92      -99.0,  -30.0,   40.0
         WD     240        2      0      0     99.17     -999.0,    0.0,  360.0
         WS     240        2      0      0     99.17     -999.0,    0.0,   50.0
      100.00 M
         TT     240        2      0      0     99.17      -99.0,  -30.0,   40.0
         WD     240        2      0      0     99.17     -999.0,    0.0,  360.0
         WS     240        2      0      0     99.17     -999.0,    0.0,   50.0

       THIS CONCLUDES THE AUDIT TRAIL
```

FIGURE 3-5d. FOURTH PAGE OF THE SUMMARY FILE FOR THE Site-specific DATA QA.

EXERCISE: Remove or comment out (by placing asterisks in the first two columns, **) the RANGE keywords in EX1-OS.INP and rerun STAGE1N2. Review the message file and note that the 'missing data' messages have been replaced with 'lower bound' violations. Why did the messages change? Examine the QA summary table - a similar changed occurred there, too.

Examine hour 11 on March 1 in the output file. Note the asterisks in the field for σ_A. Why did this happen?

EXERCISE: Add the following to the ONSITE pathway in the runstream:

NO_MISSING TT

and rerun STAGE1N2. Notice that the message file is much shorter and the number of informational messages reported in the QA table (as in Figure 3-4b) is less. The NO_MISSING keyword suppressed all QA messages and tallying that related to temperature.

3.1.3 Stage 2 - Merging Data

Since the hourly surface observations and upper air data that were processed in Stage 1 in the first example are to be used in this example, the three QA'd data files are ready for Stage 2. Figure 3-6 shows the processing flow associated with Stage 2 and Figure 3-7 shows the runstream, which is provided in EX2-MRG.INP.

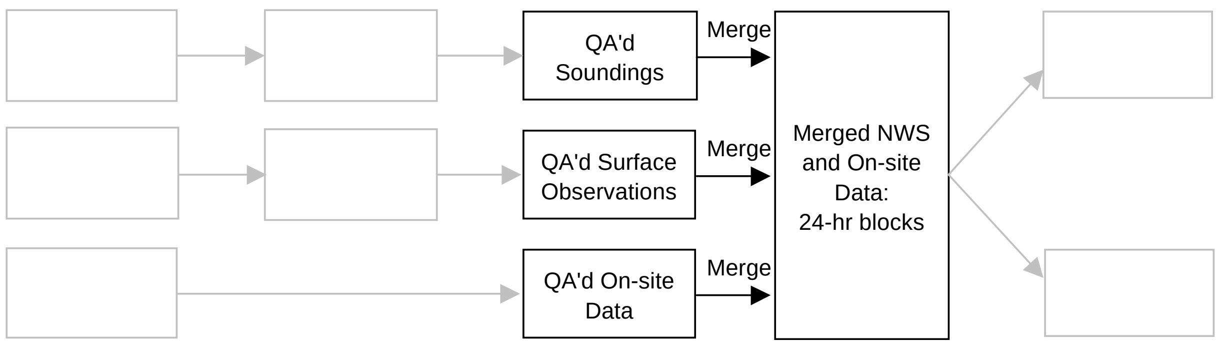

FIGURE 3-6. STAGE 2 PROCESSING THAT MERGES THE SURFACE OBSERVATIONS, SOUNDINGS, AND Site-specific DATA INTO A SINGLE FILE.

The only differences to note between this runstream and the Stage 2 runstream for Example 1 (Figure 2-10) is the inclusion of the ONSITE pathway. The output file generated in the Stage 1 QA of site-specific data, OSQAOUT.DSK, is specified with the QAOUT keyword. Also note that the file names associated with the keywords on the JOB pathway and the MERGE output were changed so as to not overwrite any of the files generated in the first example.

```
JOB                                                        Start of JOB pathway
  REPORT     MERGE-2.RPT                                      Report file
  MESSAGES   MERGE-2.MSG                                      Message file

UPPERAIR                                                   Start of UPPERAIR pathway
  QAOUT      UAQAOUT.DSK                                      UPPERAIR input file to Stage 2

SURFACE                                                    Start of SURFACE pathway
  QAOUT      SFQAOUT.DSK                                      SURFACE input file to Stage 2

ONSITE                                                     Start of ONSITE pathway
  QAOUT      OSQAOUT.DSK                                      ONSITE input file to Stage 2

MERGE                                                      Start of MERGE pathway
 OUTPUT    MERGE2.DSK                                      Output of merged meteorological data
  XDATES     88/03/01 88/03/04                             Period of observations to merge
```

FIGURE 3-7. RUNSTREAM TO MERGE NWS UPPERAIR, SURFACE DATA, AND ONSITE DATA INTO ONE FILE.

To run Stage 2 to merge the three files of meteorological data, the following command lines are used:

COPY EX2-MRG.INP STAGE1N2.INP

STAGE1N2

The message file is similar to the one generated in Example 1, so it is not shown here.

The summary report is also very similar and only the second page is shown (Figure 3-8). The only item to note is the number of site-specific observations merged each day. Rather than zero as we had in Example 1, the data base now includes 24 site-specific observation periods. The summary report also includes a fourth page (not shown here) which did not appear in the output from Example 1. It is the same as the information in Figure 3-5c.

```
       AERMET, A Meteorological Processor for the AERMOD Dispersion Model
                                Version  98314

                      Data Processed on 11-NOV-98 at 15:29:38

                         Merging the Meteorological Data

                      Merged Data Begin (Yr/Mo/Da) 88/ 3/ 1
                                   End             88/ 3/ 4

                    ***** Daily Output Statistics *****
                MO/DA  3/ 1  3/ 2  3/ 3  3/ 4
  NWS  Upper Air  Sdgs   3     4     4     4
  NWS Sfc Observations  24    24    24    24
  On-site Observations  24    24    24    24

       Upper Air Obs. Read:    9
       Surface Obs. Read:     98
       On-site Obs. Read:     97

                    ***** MERGE PROCESS COMPLETED *****
```

FIGURE 3-8. SECOND PAGE OF THE SUMMARY FILE.

3.1.4 Stage 3 - Estimating Boundary Layer Parameters for AERMOD

With all the meteorological data merged into one file, Stage 3 can be run to generate the two input files for AERMOD, as shown if Figure 3-9.

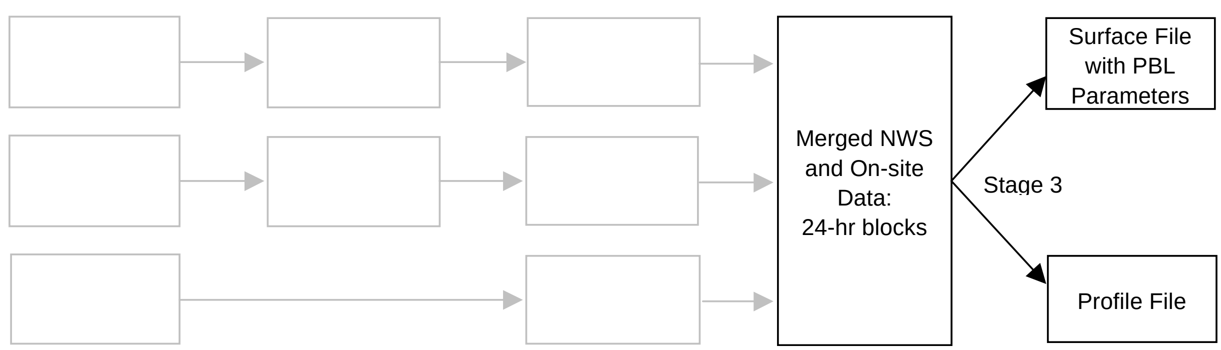

FIGURE 3-9. STAGE 3 PROCESSING USING THE MERGED NWS AND Site-specific DATA TO CREATE THE INPUT METEOROLOGY FOR AERMOD.

The input runstream for this example, shown in Figure 3-10, is identical to the runstream for Example 1 with the exception of the file names and the surface characteristics.

```
JOB                                              Start of the JOB pathway

  REPORT    STAGE3-2.RPT                               Report file

  MESSAGES  STAGE3-2.MSG                               Message file

METPREP                                          Start of the METPREP pathway

  DATA      MERGE2.DSK                                 Input file of merged
                                                       meteorological data

  LOCATION  MYSITE 74.00W 41.3N 5                      Site identifier, longitude,
                                                       latitude, and conversion to local
                                                       time

  METHOD    REFLEVEL  SUBNWS                           Processing method: allow
                                                       substitution of NWS data

  METHOD    WIND_DIR  RANDOM                           Processing method: randomize NWS
                                                       wind directions

  NWS_HGT   WIND      6.1                              NWS wind measurement height

  OUTPUT    AERMET2.SFC                                Output file with boundary layer
                                                       parameters

  PROFILE   AERMET2.PFL                                Output file with profile data

  FREQ_SECT MONTHLY 2                                  Frequency with which to specify
                                                       characteristics: period & sector

  SECTOR 1  35   225                                   Definition of the 1st wind sector

  SECTOR 2 225    35                                   Definition of the 2nd wind sector

                                                       Surface characteristics for:
  SITE_CHAR   1   1 0.350  0.800  0.300                      January, sector 1
  SITE_CHAR   2   1 0.350  0.800  0.300                      February, sector 1
  SITE_CHAR   3   1 0.350  0.800  0.300                             .
  SITE_CHAR   4   1 0.250  0.400  0.500                             .
  SITE_CHAR   5   1 0.250  0.400  0.500                             .
  SITE_CHAR   6   1 0.120  0.200  0.700                             .
  SITE_CHAR   7   1 0.120  0.200  0.700                             .
  SITE_CHAR   8   1 0.120  0.200  0.700                             .
  SITE_CHAR   9   1 0.200  0.600  0.500                             .
  SITE_CHAR  10   1 0.200  0.600  0.500                             .
  SITE_CHAR  11   1 0.200  0.600  0.500                      November, sector 1
  SITE_CHAR  12   1 0.350  0.800  0.300                      December, sector 1
  SITE_CHAR   1   2 0.500  1.500  0.750                      January, sector 2
  SITE_CHAR   2   2 0.500  1.500  0.750                      February, sector 2
  SITE_CHAR   3   2 0.500  1.500  0.750                             .
  SITE_CHAR   4   2 0.250  0.700  1.000                             .
  SITE_CHAR   5   2 0.250  0.700  1.000                             .
  SITE_CHAR   6   2 0.150  0.300  1.500                             .
  SITE_CHAR   7   2 0.150  0.300  1.500                             .
  SITE_CHAR   8   2 0.150  0.300  1.500                             .
  SITE_CHAR   9   2 0.200  1.000  1.250                             .
  SITE_CHAR  10   2 0.200  1.000  1.250
  SITE_CHAR  11   2 0.200  1.000  1.250                      November, sector 2
  SITE_CHAR  12   2 0.500  1.500  0.750                      December, sector 2
```

FIGURE 3-10. STAGE 3 RUNSTREAM.

In this example, the surface characteristics are specified MONTHLY for two unique wind direction sectors, as specified on the FREQ_SECT keyword. Hence, there must be 24 records with the SITE_CHAR keyword defining the surface characteristics.

The sectors defined for this example are 35°-225° and 225°-35°. Notice that the second sector crosses through north (360°). AERMET checks to make sure that the end point of one sector matches the start point of the next sector, and also compares the end point of the last sector with the start point of the first sector. These checks insure that surface characteristics are specified for all wind directions.

The SITE_CHAR keyword is followed by the period and sector indices. Since MONTHLY was specified, the period index ranges from 1 to 12. In this example, the albedo ranges from 0.12 in the summer when trees are in full leaf to 0.500 in winter when there is likely to be snow on the ground, the Bowen ratio ranges from 0.2 in the summer when the flow is mostly over water east of the site to 1.5 in the winter when the flow is over the hillier terrain to the west, and the roughness length ranges from 0.3 meters in the winter when the flow is mostly over water to 1.5 meters in the summer when the flow is over the fully-leafed hills west of the site.

For each hour, AERMET attempts to locate a level of wind speed and direction from the site-specific measurements to define the surface characteristics. This level is defined as the lowest level with a nonmissing wind speed and direction between $7 \cdot z_0$ and 100 meters (inclusive), where z_0 is the surface roughness length. If the only valid nonmissing wind speed is a calm wind, then the hour is treated as a calm and the reference level is the lowest level of nonmissing wind.

If there is no valid reference wind, then the lowest level is treated as the reference level and the reference wind is missing. However, if the option to substitute NWS data is specified in the runstream (see Section 4.7.6 for the keyword METHOD, secondary keyword REFLEVEL), then AERMET will substitute the NWS hourly wind speed observations for the reference wind speed and use the height specified with the keyword NWS_HGT (see Section 4.7.4) as the reference height. If NWS substitution is not specified, then the reference wind will be missing.

The selection of the reference temperature is independent of the selection of the reference wind. A valid reference temperature is defined as the lowest level with a nonmissing temperature between z_0 and 100 meters (inclusive). If there is no valid reference temperature in the site-specific data and the option to substitute NWS data is specified in the runstream, then AERMET will substitute the NWS hourly ambient temperature for the reference temperature.

To generate the two files of meteorological data for AERMOD, Stage 3 is run with the following command lines:

```
COPY EX2-ST3.INP STAGE3.INP
STAGE3
```

The message file that is created from this run is shown in Figure 3-11. There are several new messages that were not seen in Example 1. None of the message were fatal to the data processing, but serve as a way of making the user aware of some possible unusual conditions.

The first, and most frequent, of these messages in this example is the "REF WIND FROM PROFILE BELOW 20*Z0." When site-specific data are included in the data base, the definition of the reference height wind speed and direction are subject to the restrictions noted above. When the reference height for wind is below $20z_0$, then AERMET writes this warning. Record 11 in the message file indicates that AERMET could not locate site-specific data that satisfy these criteria and that NWS wind speed and direction were substituted. The presence of the METHOD keyword and secondary keyword REFLEVEL with the parameter SUBNWS included in the runstream (Figure 3-7) directed AERMET to make the substitution. Recall that all the site-specific data were missing for hour 11 on March 1, hence this message is appropriate. A similar substitution was made for the ambient air temperature (record 12). Of course, the substitutions are subject to the NWS data not being missing for the hour.

The final message to note is 17 records from the bottom: "NET RAD'N < 0 DURING DAY." This message indicates that AERMET has calculated a downward net radiation between sunrise and sunset for the hour shown. For this condition, the hour is treated as stable. This condition is often caused by positive incoming radiation, but a larger value of outgoing long-wave radiation.

```
       METPREP    I19 ST3SET: "END OF FILE" ON UNIT  5 AFTER RECORD #  42
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 01
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 02
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 03
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 05
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 06
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 07
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 08
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 09
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 10
880301 METPREP    I81  SUBST: NWS WINDS       SUBST'D FOR ONSITE FOR HR: 11
880301 METPREP    I82  SUBST: NWS TEMPERATURE SUBST'D FOR ONSITE FOR HR: 11
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 12
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 13
880301 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 14
  .      .         .     .          .                       .
  .      .         .     .          .                       .
  .      .         .     .          .                       .
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 08
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 09
880304 METPREP    W77  MPPBL: NET RAD'N < 0 AFTER SUNRISE FOR HR: 09
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 10
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 11
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 12
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 13
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 14
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 15
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 16
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 17
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 18
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 19
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 20
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 21
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 22
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 23
880304 METPREP    W80  SUBST: REF WIND FROM PROFILE BELOW 20*Z0 FOR HR 24
     5 METPREP    I79  FETCH: EOF ON INPUT DATA FILE AFTER 880304
```

FIGURE 3-11. MESSAGE FILE FROM STAGE 3.

The summary report file is identical in nature to the summary report for Stage 3 in Example 1. Rather than keep repeating the same or similar information about the report file, the user is left to compare the two Stage 3 report files from Examples 1 and 2.

EXERCISE: How are the report files from Stage 3 in Examples 1 and 2 different? What are the similarities?

EXERCISE: Remove or comment out (by placing two asterisks in columns 1 and 2) the METHOD REFLEVEL SUBNWS record in EX2-ST3.INP and rerun Stage 3 (change the output file names so the different runs can be compared). Are the NWS data substitution messages still present? Compare the boundary layer parameter output files - how have the results changed for March 1, hour 11?

EXERCISE: In any of the runstreams that have been presented in Sections 2 and 3, add the CHK_SYNTAX keyword to the JOB pathway and rerun the appropriate program (STAGE1N2 or STAGE3). What is displayed on screen? What are the contents of the output files?

Note: even if the only activity is to check the runstream syntax, AERMET still opens files, so it is possible that some zero-byte files will appear or files only with header records will appear. It is best to delete these files before running AERMET without the CHK_SYNTAX keyword.

3.2 COMBINING OR SEPARATING PROCESSING STEPS

These examples required several separate runs to generate the boundary layer parameters. However, several steps in Stage 1 can be combined to reduce the number of times the programs must be run, but AERMET always requires a minimum of three separate steps to process the data - one step for each stage of processing.

One example of combining steps was used throughout the tutorial - the extract and QA of data was performed in one run. Another way to combine steps is to extract and QA all available data types - hourly surface observations, upper air data, and site-specific data - in one run. It is really a concatenation of several of the runstream files above, but with one JOB pathway rather than three. The advantage to this procedure is in minimizing the number of input runstream files and the time spent in running Stage 1. The disadvantage is that an error in one data type stops the processing. Any data type(s) processed prior to the error would be completed successfully; the data type in which the error occurred is partially completed; and data type(s) that are to be processed subsequent to the error are not processed.

```
JOB
  MESSAGES  ANYNAME.MSG
  REPORT    ANYNAME.RPT

SURFACE
  DATA      S1473588.144  CD144
  EXTRACT   SFEXOUT.DSK
  XDATES    88/3/1  TO  88/3/10
  LOCATION  14735  42.75N  73.8W  0
  QAOUT     SFQAOUT.DSK

UPPERAIR
  DATA      14735-88.UA  6201FB  1
  EXTRACT   UAEXOUT.DSK
  XDATES    88/3/1 TO 88/3/10
  LOCATION  00014735  73.80W  42.75N  5
  QAOUT     UAQAOUT.DSK
  AUDIT     UATT  UAWS  UALR

ONSITE
  DATA      ONSITE.MET
  XDATES    88/3/1 TO 88/3/10
  LOCATION  99999 74.0W 41.3N  0
  QAOUT     OSQAOUT.DSK

  READ 1 OSDY OSMO OSYR OSHR HT01 SA01 SW01 TT01 WD01 WS01
  READ 2                     HT02 SA02 SW02 TT02 WD02 WS02
  READ 3                     HT03 SA03 SW03 TT03 WD03 WS03
  FORMAT 1 (4(I2,1X),4X,F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)
  FORMAT 2 (16X,        F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)
  FORMAT 3 (16X,        F5.1,1X,F5.1,1X,F7.3,1X,F6.2,1X,F7.2,1X,F7.2)
  RANGE TT -30 < 40 -99
  RANGE SA 0 <= 95  -99
  RANGE WS 0 < 50   -999
  RANGE WD 0 <= 360 -999
  THRESHOLD  0.3
```

FIGURE 3-12. RUNSTREAM TO EXTRACT AND QA ALL DATA TYPES IN ONE RUN.

Another alternative in Stage 1 is to perform the extraction and QA separately, increasing the number of times STAGE1N2 is run. This can be done for the UPPERAIR and SURFACE pathways. There is only one step for the ONSITE pathway since the data can only be QA'd. This could be useful if the data are likely to be QA'd more than once. The combinations of the keywords DATA, EXTRACT, and QAOUT direct AERMET on how to process the data, as follows:

DATA	&	EXTRACT	&	QAOUT	➠ extract and QA
DATA	&	EXTRACT			➠ extract
		EXTRACT	&	QAOUT	➠ QA (UPPERAIR and SURFACE)
DATA	&			QAOUT	➠ QA (ONSITE only)

For example, in EX1-SF.INP, remove or comment out the line

QAOUT SFQAOUT.DSK

and run STAGE1N2. The SURFACE data are extracted but not QA'd. To QA the data, a new runstream has to be constructed. This new runstream will have a JOB pathway and a pathway for the SURFACE data. For example, the following runstream might be used:

```
JOB
MESSAGES   QAONLY.MSG
REPORT     QAONLY.MSG
SURFACE
EXTRACT    SFEXOUT.DSK
QAOUT      SFQAOUT2.DSK
```

Try running this runstream and comparing the resulting message and summary report files with the ones generated using EX1-SF.INP. Also compare the output files (notice that the name was changed here so as not to overwrite the one created with EX1-SF.INP - AERMET will not warn you if a file is being overwritten!). Note here that no blank lines were used and keywords are not indented in the runstream. AERMET reads this runstream without any problem, but the user might have a more difficult time.

SECTION 4

KEYWORD REFERENCE

This section provides a detailed reference for all the keywords available in AERMET, expanding the discussion of the keywords presented in Sections 2 and 3 and explaining those keywords that were mentioned but not discussed. The discussion in this section assumes that the reader has a basic understanding of the pathway, keyword and parameter approach. Novice users should review Section 2.1 to obtain a basic knowledge of the approach.

The information in this section is organized by pathway, with the more commonly used keywords for that pathway discussed first. The syntax for each keyword is provided using dummy parameter names. The keyword types - mandatory or optional, repeatable or nonrepeatable, reprocessed - are specified. The definition of these terms is discussed below. Additionally, any special requirements, such as the order within the pathway, are specified.

4.1 DEFINITIONS AND RUNSTREAM FILE PROCESSING

The terms "mandatory" and "optional" indicate whether the keyword for a particular pathway is required to run AERMET (mandatory) or if it enhances or modifies the processing (optional). Several keywords may be mandatory or optional depending on the point they are used in the processing and the data. For example, QAOUT serves two purposes: to define the output file for Stage 1 QA and to define the input file for Stage 2 merge. While data QA is optional in Stage 1, the keyword is mandatory if the data for the pathway are to be merged in Stage 2. A distinction will be made when the keyword type may be ambiguous. For the discussions in Sections 4.2 - 4.5, the stages to which the keyword refers will be in parentheses following the terms "mandatory" and "optional". If 'All' is specified, then the keyword applies to all stages of processing.

The terms "repeatable" and "nonrepeatable" refer to whether or not the keyword can appear only once (nonrepeatable) or more than once (repeatable) <u>for the same pathway</u> in a runstream. For example, the MESSAGES keyword can appear only once on the JOB pathway, thus it is nonrepeatable. However, the RANGE keyword for assessing the validity of the data can appear multiple times on a pathway, thus it is repeatable. A nonrepeatable keyword may appear multiple times in a runstream file, but only once per pathway. For example, the QAOUT keyword defines the input file for each pathway for Stage 2 (merging data). It can appear only once for each pathway, but it will appear two or three times in the runstream because there is usually more than one type of data to merge.

When AERMET processes meteorological data in Stage 1 and Stage 2, runstream records used to control the preprocessor's actions are written at the top of the output file(s). These records are referred to as header records. Special symbols are added at the beginning of some of these records that direct AERMET to reprocess the header record when it is read from the data file, i.e., the headers are read and processed as if they had been included as a part of the current runstream. If a keyword can be reprocessed, then the keyword type includes the term "reprocessed". By allowing AERMET to reprocess a header record, the user does not have to specify certain keywords for subsequent runs. The best example of this is for the ONSITE pathway on which the user must specify the structure of the data. Specify them once and AERMET will use the information to read the data in subsequent runs.

☞ **The output files specified in the runstreams are created and/or opened and the header records are written to the file(s). If a run should generate a setup error, subsequent runs after the error is corrected may reintroduce the error (due to header reprocessing). Therefore, if a run generates an error, it is recommended that the user delete the <u>output</u> files before rerunning AERMET.**

Except for a couple keywords, there are no special requirements for the order of the keywords within each pathway, but it is recommended that a logical order be maintained to be able to understand the processing defined by each runstream file.

The syntax descriptions in the following sections use certain conventions. The keywords are all uppercase and the parameters are all lower case. Square brackets around a parameter indicate that the parameter is optional and a default value may be used if it is omitted.

A word of caution that deserves repeating: for an AERMET run, all output files are opened with STATUS = 'UNKNOWN'. With this specifier, if the file already exists, AERMET will open it without providing any opportunity to save it. With the first write action to the file, the contents of an existing file are erased. Before running AERMET, the user should be certain that any output file name specified in a runstream file either does not exist or can be overwritten.

4.2 JOB PATHWAY

The JOB pathway appears in all AERMET runstream files. The primary purpose of the JOB pathway is to specify the file names for reporting all the preprocessor actions that are performed for the particular run.

4.2.1 Messages From AERMET - MESSAGES

All error, warning, informational, and QA messages issued by AERMET are written to the file name specified with the MESSAGES keyword. The contents of this file are discussed throughout the tutorial in Sections 2 and 3 and in Appendix D. This keyword is mandatory because the program later interrogates this file to summarize the processing. The syntax and type are:

Syntax:	MESSAGES *message_filename*
Type:	Mandatory (All), Nonrepeatable

The *message_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters.

4.2.2 Run Summary - REPORT

At the conclusion of a run, AERMET interrogates the file of messages, tabulates the different types of messages (errors, warnings, etc...), and summarizes all the actions for that particular run in a file specified with the REPORT keyword. The contents of a run summary are discussed throughout the tutorial in Sections 2 and 3. The syntax and type for this keyword are:

Syntax:	REPORT *summary_filename*
Type:	Optional (All), Nonrepeatable

The *summary_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters.

This keyword is optional. If it is omitted, then the summary is written to the output control device connected to logical unit 6. On a personal computer, this unit is normally the video monitor. This information can be captured using redirection (as discussed in Section 2).

4.2.3 Checking the Runstream File for Errors - CHK_SYNTAX

AERMET processes all the statements in a runstream file prior to processing any data. Incomplete information on a keyword or the omission of a keyword will cause AERMET to terminate the run. The CHK_SYNTAX keyword directs AERMET to process the runstream file and report any problems without performing any data processing. The user can review the summary and message files and correct any errors or make any changes to the runstream file prior to actually processing data. WARNING: AERMET opens all output files and writes the header records to those files, overwriting any data in the file if the file existed. The syntax and type of the CHK_SYNTAX keyword are:

Syntax:	CHK_SYNTAX
Type:	Optional (All), Nonrepeatable

No parameters accompany this keyword.

The user gets a full report of the processing of the runstream file, i.e., the MESSAGES file and REPORT file are generated and can be reviewed. In the REPORT file, the following appears near the top of each page in the file:

```
****************************************************
***   THIS RUN ONLY CHECKS THE RUNSTREAM SETUP   ***
****************************************************
```

The message also appears on the screen at the conclusion of a run that only checks the syntax.

4.3 SURFACE PATHWAY

The SURFACE pathway defines all the necessary information for processing National Weather Service hourly surface weather observations or surrogate data that complies with an established format. These data provide information on temperature, winds, and cloud cover (particularly important) that can be used in estimating dispersion parameters. The data generally come from first order observation stations (observations 24 hours per day) located at or near airports. AERMET can read and process a variety of formats, each discussed below with the DATA keyword.

4.3.1 Retrieving Archived Data - DATA

Hourly NWS surface observations are stored in a variety of compact formats. Data stored in one of these formats is referred to as archived data. One of AERMET's functions is to read and interpret the archived data and to write the results in another format for later processing.

AERMET can interpret three different archive file formats of hourly surface data that are available for processing on a PC. A fourth format can be processed that is primarily available on magnetic tape. The DATA keyword is used to specify the file name and define the archive file format for AERMET. The syntax and type for the DATA keyword are:

Syntax:	DATA *archive_filename file_format* [*blocking_factor*] [*type*]
Type:	Mandatory (Stage 1), Nonrepeatable

The *archive_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of the *archive_filename* is 48 characters.

For processing archive data on a PC, the *file_format* must be specified as one of the following: CD144, SCRAM or SAMSON. Each of these formats is discussed in more detail below. AERMET also processes a format that is available on magnetic tape: TD-3280. This format is discussed in Appendix E.

The *blocking_factor* defines the number of logical records in one physical record for fixed-length logical records and is intended primarily for use with magnetic tapes. One logical record is composed of data for a single observation period, and one physical record is composed of one or more logical records. The default value for this factor is 1; it can be omitted in most applications. Additional information on the *blocking_factor* for data on magnetic tapes is discussed in Appendix E.

The last field on the DATA record, *type*, indicates whether the data follow the ASCII or EBCDIC collating sequence. The default collating sequence is ASCII. The EBCDIC collating sequence refers to processing data on magnetic tape, and in particular tapes on an IBM mainframe computer, and is not required for processing data on a personal computer. Unless AERMET is processing data on an IBM mainframe computer, this field can be left blank. If this parameter is specified, then the *factor* must also be specified.

4.3.1.1 CD-144 and SCRAM Formats

The CD144 format is an older standard format used by the National Climatic Data Center for archiving surface observations. Alphanumeric characters are used to represent various weather elements. All the weather elements for one hour are stored on one logical record and the length of each logical record is 79 characters.

When requesting hourly surface data from NCDC, the user must make a specific request for the CD144 format because this standard was replaced in the 1980's by a new standard, the TD-3280 format. This new standard is an element-based format in which all observations for a single weather element (e.g., dry bulb temperature) for an entire day are stored as contiguous data. This format, however, does not lend itself directly to processing on personal computers. A discussion of the TD-3280 format and data processing can be found in Appendix E.

The SCRAM format is a reduced version of the CD144 format and is available from the EPA's Technology Transfer Network electronic bulletin board under the Support Center for Regulatory Air Models (SCRAM) section. Fewer weather elements are reported. Each logical record is 28 characters and includes data for cloud ceiling height, dry bulb temperature, wind speed and direction, and opaque sky cover. AERMET requires surface station pressure for some of its computations (e.g., density of air). The SCRAM format does not include station pressure and sea level pressure in a standard atmosphere (1013.25 millibars) is assumed when this format is used.

AERMET operates on a 01 - 24 clock but these two formats report data on the 00 - 23 clock. Hour 00 is hour 24 of the previous day. Thus, when data are retrieved from an archive file for a specific time period, the first hour is discarded since it is prior to the beginning time. Likewise, since the data for a day end with hour 23, the last day in the extracted data file will only have 23 hours.

AERMET reads several of the columns in the CD-144 format as character since numbers or letters could appear in those columns. AERMET then attempts to decipher/decode these columns by comparing the character it has read with a list of valid characters. If there is no match, then AERMET issues a warning on which overpunch position could not be deciphered. The following table lists the correspondence between the overpunch character and column in the CD-144 format. Note: The term 'overpunch' refers to the 'old' days when 80-column computer cards were used and the amount of information on a single card was limited. Overpunches conserved space and were produced by pressing the overpunch key and pressing a numeric value (0-9) and another key, usually the sign of the number. This overpunch technique generated a character rather than a numeric value, which is what AERMET is trying to decode.

Overpunch position(s)	CD-144 columns	CD-144 element
1-3	14-16	Ceiling height
4	17	First sky cover layer
5	18	Second sky cover layer
6	19	Third sky cover layer
7	20	Fourth sky cover layer
8	36	Sign of the dew point (X ⇒ dew point < 0)
9	**41**	**1st digit of wind speed (X⇒speed >100 kt)**
10	**47**	**Sign of the dry bulb (X ⇒ dry bulb < 0)**
11	50	Sign of the wet bulb (X ⇒ wet bulb < 0)
12	**56**	**Total sky cover**
13-34	57-78	Cloud data by layer
35	**79**	**Opaque sky cover**

The data associated with overpunches 9, 10, 12, and 35 (in bold above) may be used by AERMET, depending on the availability of other (e.g., site-specific) data. The other fields are decoded, but the weather information contained in them currently are not used by AERMET.

4.3.1.2 SAMSON Format

With the advent of inexpensive compact disc technology for the personal computer, large amounts of data can be stored in small amounts of space. NCDC has made available solar and meteorological data for the first order stations in the United States for the period 1961-1990 on a set of three CD-ROMs, collectively referred to as the SAMSON data. AERMET processes the data retrieved from these CD-ROMs.

☞ **AERMET cannot access the data directly on a SAMSON CD-ROM**.

Rather, the user must run the software provided with the data to retrieve the station(s), period(s) of time and variables for the site and period to be modeled. The software is a DOS-based, interactive graphical interface. The output files are written as an ASCII file on the user's local drive. It is this output that AERMET processes.

Retrieving the meteorological data from the CD-ROM is completely under the control of the user, i.e., the user specifies which meteorological elements to retrieve from a list of 21 elements stored for each station. For the current version of AERMET, the following elements should be retrieved: ceiling height, wind direction and speed, dry bulb temperature, opaque cloud cover, total sky cover, and station pressure. These elements result in an ASCII file of about 450 Kb for one year of meteorological data. If all 21 variables are retrieved, then a file size of about 1.2 Mb is created, although the file size will vary because precipitation data (in field 21) are reported only if there was precipitation for the hour, making some records longer than others.

When the data are retrieved from the CD-ROM, two records are written at the beginning of the file that identify the station (first record) and the variables retrieved (second record). These two initial records, or headers, begin with the tilde character (~). AERMET processes both of these records to obtain information about the station (e.g., station WBAN number) and to determine how to process the data that follow. It is imperative that the user not alter or delete these records.

If more than one year of data are retrieved from the CD-ROM, then two records beginning with the tilde appear before each year in the file. When the second set of headers is encountered, AERMET will print a warning in the message file and continue processing data. It is recommended that the user restrict data retrieved from CD-ROM to one station and one year per file or edit a multi-year file such that there is only one year per file.

The header records are followed by the data records. There is one record for each hour of the time period the user retrieved. Unlike the CD-144 format which reports the hour on the 00 - 23 clock, the hour is reported on the 01 - 24 clock, which is consistent with AERMET data processing.

4.3.2 Saving Dearchived Data - EXTRACT

The EXTRACT keyword specifies the file name to which the data retrieved from the archive file are written. The syntax and type are:

Syntax:	EXTRACT *extracted_data_filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *extracted_data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters.

4.3.3 Extracting a Subset of the Data - XDATES

The amount of data extracted from an archive file can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field, and there cannot be any spaces within a date group because the space is used as a delimiter between parameter fields. The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

4.3.4 Identifying the Station - LOCATION

One station and one year of data are generally in a file on a personal computer, whereas multiple stations and multiple years of data may exist on magnetic tape. To allow AERMET to process data on multiple computer platforms, information on which station's data to extract from the archive file is required, even for personal computer-based data. The LOCATION keyword performs this function. The parameters on this keyword specify the station identifier, latitude and longitude, and a time adjustment factor to adjust the data to local standard time. The syntax and type are:

Syntax:	LOCATION *site_id* *NWS_lat/long* *NWS_long/lat* [*tadjust*]
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is a five character alphanumeric specifier that identifies the station for which data are to be extracted. For the standard formats listed on the DATA keyword, these identifiers are five-digit WBAN (Weather Bureau Army Navy) numbers. The *site_id* must be specified with leading zeros to fill the entire field (e.g., 03928 must be entered as 03928) since the field is read as a type character and not an integer. A master list of WBAN numbers for stations throughout the world can be obtained from NCDC.

The NWS station latitude (*lat*) and longitude (*long*) can be entered in either order because AERMET distinguishes between the two by the suffix on each: an N or S with the latitude and

W or E with the longitude. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N" in AERMET. AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north and south and east and west. Therefore, the latitude and longitude should always be specified as positive numbers. The NWS latitude and longitude on the SURFACE pathway are not used for any purpose at this time. They are simply another way to identify the NWS station being processed.

The final parameter for this keyword, *tadjust*, is an adjustment factor that is subtracted from the reported hour to convert the time to local standard time. For stations west of Greenwich, a positive number should be specified. The default value for *tadjust* is zero. The NWS surface data formats processed by AERMET report the time as local standard time. Therefore, *tadjust* is zero in most applications, and because zero is the default value, it can be omitted. This parameter is retained in AERMET to provide flexibility in processing other data types should they need the time adjusted and to maintain consistency with the keyword usage on other pathways.

4.3.5 How good are the data? - QAOUT

One purpose of AERMET is to contribute to the quality assurance process by identifying data that are out of range or suspect such that the user can determine appropriate steps to accept, modify, or reject the data. The quality assessment (QA) is performed by including the QAOUT keyword in a runstream. This keyword is also used to specify the input file to Stage 2. The syntax and type for the QAOUT keyword are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2) if there are data to merge, Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters. For one year of data, the size of the output file is approximately 1.3 Mb.

Quality assessment is an optional process and the user does not have to perform a QA prior to merging the data. However, this step is recommended to identify possible errors in the data that are used to derive the boundary layer parameters.

Presently, AERMET's capabilities in this area are limited to verifying that the values of the weather elements are not outside a range of 'acceptable' values and keeping track of the number of missing values. These checks operate on one observation period at a time, i.e., temporal variations of the data are not checked.

On the SURFACE pathway, when a quality assessment is performed, several of the weather elements are automatically tracked (audited) and included in a summary of the QA process. These elements are: station pressure, total and opaque sky cover, dry bulb temperature, wind speed, and wind direction. The hourly value of each variable is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. Each time a value is missing or violates one of the bounds, a message is written to the message file defined by the MESSAGES keyword. The message includes the value, the violation, and the time of occurrence. The date is reported in the first field in the message. The number of times the weather element is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file defined on the REPORT keyword.

In the current version of AERMET there are no provisions for automatically replacing missing values or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace the value in question or leave it alone.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator. These values can be changed by the user through the use of the RANGE keyword, as described below. Also, the user can QA additional weather elements by using the AUDIT keyword.

4.3.6 Adding Weather Elements to the QA - AUDIT

As mentioned in the previous section, there are only five weather elements that are tracked by default during a QA. The user can track additional weather elements for a particular AERMET run by specifying the element name with the AUDIT keyword. The syntax and type for this keyword are:

Syntax:	AUDIT *sfname*1 ... *sfname*n
Type:	Optional (Stage 1), Repeatable

where *sfname*1, ..., *sfname*n are the internal AERMET names of the weather elements as defined in Table B-2 of Appendix B. As many names can be specified on a single keyword that will fit within the 80-character limitation of a keyword. Since this keyword is repeatable, more than one AUDIT keyword can be used to define all the additional elements to track.

While the AUDIT keyword can add weather elements to the QA, there is no method to remove any of the default weather elements from the QA. They are always reported.

4.3.7 Changing the Default Values for the QA - RANGE

The user can modify the upper or lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well and is the most likely reason this keyword is used. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *sfname* *lower_bound* <[=] *upper_bound* *missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *sfname* is the internal AERMET name of the weather element as defined in Table B-2 of Appendix B, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in the QA, and *missing_indicator* is a new missing value code. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified for this keyword; if a parameter is not changing, the default value should be specified.

Data for the SURFACE pathway are written as integers with some variables having been multiplied by 10 when extracted to retain significant digits. Table B-2 provides information on which variables use a multiplier. The default upper and lower bounds are multiplied also, therefore, the user must multiply any new upper and lower bounds by the same multiplier when entering the data on the RANGE keyword. However, the multiplier is not applied to the *missing_indicator*.

Several weather elements have been concatenated to form a single variable in the *extracted_data_file*. These variables are noted in Table B-2 and are related to cloud cover, weather type and height (locate the double slash (//) in the descriptions). If the user wants to modify the bounds and the missing value indicator through a RANGE keyword, these values must be concatenated, also.

4.3.8 Reducing the Number of QA Messages - NO_MISSING

Every time a bound is violated or a value is missing, a message is written to the message file (defined on the MESSAGES keyword). If one weather element that is tracked for reporting (either by default or defined on an AUDIT keyword) is missing most of the time (e.g., station pressure in a SCRAM archive file), the message file could become very large. To reduce the number of missing value messages and the size of the message file, the NO_MISSING keyword can be included for the QA. The syntax and type are:

Syntax:	NO_MISSING *sfname*1 ... *sfname*n
Type:	Optional (Stage 1), Repeatable

where *sfname*1, ..., *sfname*n are the internal AERMET names of the weather elements to omit from the message file. The missing values are not tallied or reported in the summary file when this keyword is used.

4.4 UPPERAIR PATHWAY

The UPPERAIR pathway defines all the necessary information for processing National Weather Service rawinsonde (sounding) data. These data provide information on the vertical structure of the atmosphere. The height, pressure, dry bulb temperature, relative humidity (which is used to obtain dew point temperature) and winds are reported. The data come from about 50 stations around the United States, and most countries in the world have an upper air observation program. The data are generally collected twice-daily, at 0000 Greenwich Mean Time (GMT) and 1200 GMT (these times are also referred to as 00Z and 12Z, respectively).

AERMET can read and process one format, as discussed below with the DATA keyword. However, surrogate data can be used if the user can reformat data into a format that is ready for Stage 1 QA (i.e., skip the extraction process). AERMET has been designed to accept 24 soundings per day. Note though, for AERMET to correctly read the file, a minimum of one header record consisting of three asterisks (in columns 1-3) must appear on a separate record before the data (these asterisks inform AERMET that there are no more headers to process).

4.4.1 Retrieving Archived Data - DATA

NWS rawinsonde data are stored in a variety of formats. However, AERMET is designed to read only one of those formats. As with hourly surface observations, data stored in this format is referred to as archived data. AERMET reads and interpret the sounding data and writes it to a separate file for later processing. The DATA keyword is used to specify the file name and define the archive file format for AERMET. The syntax and type for the DATA keyword are:

Syntax:	DATA *archive_filename file_format* [*blocking_factor*] [*type*]
Type:	Mandatory (Stage 1), Nonrepeatable

The archive file must conform to the naming conventions appropriate to the computing platform. The maximum length of the archive file is 48 characters.

AERMET processes the TD-6201 series data available from NCDC. The structure of the upper air archive format can be found in NCDC's documentation for the TD-6200 series data (NCDC, 1989). When TD-6201 upper air data are ordered on diskette from NCDC, the data are stored as fixed-length records, i.e., the length of each record is the same. For this type of structure, the *file_format* must be specified as 6201FB. The 6201 associates the particular data format that AERMET can process, and the FB indicates fixed-length records. In this archive format, there can be up to 200 levels reported per sounding spanning three physical records on the diskette. Each physical record consists of 2876 characters, with the first 32 characters used to identify the sounding followed by 36 characters per sounding level, with a maximum of 79 levels reported on the first record. If there are less than 79 levels, then missing data indicators are used to 'fill out' a record such that the physical record length is constant for all observation periods. If there are between 80 and 158 sounding levels, then a second record is present in the data. For more than 158 sounding levels, a third record is present. AERMET only processes the first physical record, skipping any additional records for a single sounding because the measurements at the 79th level are generally above 16,000 meters, and more likely above 20,000 meters.
Currently, AERMET does not use information above about 5000 meters, therefore the second and third records, if they exist, are skipped.

The upper air data can be ordered on magnetic tape for use on other computing platforms.

Processing data on magnetic tape is discussed in Appendix E. Generally, data on magnetic tape are requested and delivered as variable-length because this format is most efficient at storing data - only those sounding levels at which data are observed are in the archive file.

The *blocking_factor* defines the number of logical records (soundings) in one physical record and is intended primarily for use with magnetic tapes. The default value is one and this value cannot be less than one. For data on diskette, there is one logical record per physical record and, because the default is one, this parameter can be omitted. As explained above, a single sounding in fixed-block format on a diskette may require more than one record to complete the sounding. The blocking factor is still one for this case. For data on tape, however, the *blocking_factor* may be greater than one. Additional information on the *blocking_factor* for magnetic tapes can be found in Appendix E.

The last field on the DATA record, *type*, specifies whether the data follow the ASCII or EBCDIC collating sequence. The default collating sequence is ASCII and can be left blank when processing data on a personal computer. The EBCDIC collating sequence is for processing data on an IBM mainframe computer. If this parameter is specified then the *factor* must also be specified.

4.4.2 Saving Dearchived Data - EXTRACT

The EXTRACT keyword specifies the file name to which the data retrieved from the archive file are written. The syntax and type are:

Syntax:	EXTRACT *extracted_data_filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *extracted_data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters.

4.4.3 Extracting a Subset of the Data - XDATES

The amount of data extracted from an archive data file can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces within a date group since a space is used as a delimiter between parameter fields. The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

4.4.4 Identifying the Station - LOCATION

One station and one year of data generally are in a file on a personal computer, whereas multiple stations and multiple years of data are likely on magnetic tape. AERMET requires information on which station's data to extract from the archive file, even for personal computer-based data. The LOCATION keyword performs this function. The parameters on this keyword specify the station identifier, latitude and longitude, and a time adjustment factor to correct the data to local standard time. The syntax and type are:

Syntax:	LOCATION *site_id* *NWS_lat/long* *NWS_long/lat* [*tadjust*]
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is an eight character alphanumeric specifier that identifies the station for which data are to be extracted. For the standard format listed on the DATA keyword, these identifiers are five-digit WBAN numbers. However, the *site_id* must be specified with leading zeros to fill the entire eight-character field (e.g., 14735 must be entered as 00014735) since the field is read as type character and not as an integer.

The NWS station latitude (*lat*) and longitude (*long*) can be entered in either order because AERMET distinguishes between the two by the suffix on each: an N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N" in AERMET. AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north and south and east and west. Therefore, the latitude and longitude should always be specified as positive numbers. The NWS latitude and longitude on the UPPERAIR pathway are not used for any purpose at this time. For this version of AERMET, they are simply another way to identify the station being processed.

The final parameter for this keyword, *tadjust*, is optional and is an adjustment factor to convert the time of each observation in the input data file from the reported time to local standard time. The default value for *tadjust* is zero. For NWS upper air data processed by AERMET, the reported time is Greenwich Mean Time. The value for *tadjust* is subtracted from GMT to obtain local standard time. Therefore, in the United States, which is west of Greenwich, the value 5 is specified to convert GMT to Eastern Standard Time, 6 is specified to convert GMT to Central Standard Time, 7 is specified to convert GMT to Mountain Standard Time, and 8 is specified to convert GMT to Pacific Standard Time.

4.4.5 How good are the data? - QAOUT

One purpose of AERMET is to contribute to the quality assurance process by identifying data that are out of range or suspect such that the user can determine appropriate steps to accept, modify, or reject the data. The quality assessment (QA) is performed by including the QAOUT keyword in a runstream. This keyword is also used to specify the input file for Stage 2. The syntax and type for the QAOUT keyword are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2) if there are data to merge, Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters. For one year of TD-6201 data, the size of the output file is approximately 0.5 Mb.

Quality assessment is an optional process and the user does not have to perform a QA prior to merging the data. However, this step is recommended to identify any potential problems in the data that are used to derive the dispersion parameters.

Presently, AERMET's capabilities in this area are limited to verifying the values of the upper air data are not outside a range of acceptable values and keeping track of the number of missing values. These checks operate one sounding at a time, i.e., sounding to sounding variations are not checked.

Unlike the SURFACE pathway, there are no variables that are tracked (audited) automatically on the UPPERAIR pathway. The user must specify those variables to QA through the AUDIT keyword, as discussed below. For each of the specified variables, the value of each variable at each level is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. Each time a value is missing or violates one of the bounds, a message is written to the message file containing the value, the violation, the date and time of occurrence and the sounding level. The number of times the variable is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file (defined on the REPORT keyword).

The number of levels in a sounding and the heights at which the data are recorded vary from sounding to sounding. It is impractical to report on every level. AERMET divides the atmosphere into 10 regions in which to summarize the QA information for the soundings. These regions are based on the thickness increment defined to be 500 meters (in the variable UAINC in the file MASTER.INC). These regions are: surface (the first level in the sounding), every 500 meters up to 4000 meters and everything above 4000 meters. By changing the value of UAINC (and recompiling the software), these regions could be increased or decreased.

In the current version of AERMET there are no provisions for automatically replacing missing values or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace the value in question or leave it alone.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator for each variable. These values can be changed by the user through the use of the RANGE keyword, as described below.

4.4.6 Adding Upper Air Variables to the QA - AUDIT

As mentioned above, there are no upper air variables that are tracked by default during a QA. The user can track some or all variables for a particular AERMET run by specifying the variable names on an AUDIT keyword. The syntax and type for this keyword are:

Syntax:	AUDIT *uaname*1 ... *uaname*n
Type:	Optional (Stage 1), Repeatable

where *uaname*1, ..., *uaname*n are the upper air variable names as defined in Table B-1 of Appendix B. As many variable names can be specified on a single keyword that will fit within the 80-character limitation of a keyword. Since this keyword is repeatable, more than one AUDIT keyword can be used to define the variables to track.

4.4.7 Changing the Default Values for the QA - RANGE

The user can modify the upper and lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *uaname* *lower_bound* <[=] *upper_bound* *missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *uaname* is the upper air variable as defined in Table B-1 of Appendix B, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in the QA, and *missing_indicator* is a new missing value indicator. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified for this keyword even if a parameter is not changing; if a parameter is not changing, the default value should be specified.

Data for the UPPERAIR pathway are written as integers to the output file with some variables having been multiplied by 10 to retain significant digits. Table B-1 provides information on which variables use a multiplier. The default upper and lower bounds are multiplied as well, therefore, the user must multiply any new upper and lower bounds by the same multiplier when entering the data on the RANGE keyword. However, the multiplier is not applied to the *missing_indicator*.

4.4.8 Reducing the Number of QA Messages - NO_MISSING

Every time a bound is violated or a value is missing, a message is written to the message file (defined on the MESSAGES keyword). If a variable that is tracked is missing most of the time, the message file could become very large. To reduce the number of missing value messages and the size of the message_file, the NO_MISSING keyword can be included for the QA. The syntax and type are:

Syntax:	NO_MISSING *uaname*1 ... *uaname*n
Type:	Optional (Stage 1), Repeatable

where *uaname*1, ..., *uaname*n are the variable names of the weather variables to omit from the message file. The missing values are not tallied or reported in the summary file when this keyword is used.

4.4.9 Adjusting Sounding Data - MODIFY

AERMET has been designed to check for other problems with the upper air data and correct them if the keyword is used. The MODIFY keyword directs AERMET to 'turn on' the process and perform some preliminary quality control as the data are extracted. The syntax and type of the keyword are:

Syntax:	MODIFY
Type:	Optional (Stage 1), Nonrepeatable

This keyword does not have any parameters associated with it. By specifying this keyword, the following actions occur:

- Some mandatory levels are deleted from the sounding;
- A nonzero wind direction is set to 0 if the wind speed is 0;
- Missing ambient and dew point temperatures are replaced by interpolated values.

If a mandatory sounding level is within one percent of a significant level (with respect to pressure) then the mandatory level is deleted. This modification is performed to reduce the possibility of reporting large gradients during the quality assessment (if the user opts to QA those gradients). There is little loss of information in the sounding since mandatory levels are derived from significant levels. However, the deletion process takes place after the data are extracted from the archive data and reduces the number of levels extracted. AERMET does not attempt to read more levels after deleting a level.

The wind speed and wind direction at each level are checked to insure that there are no levels with a zero wind speed and a non-zero wind direction. If one is found, the wind direction is set to zero to represent calm conditions. At present, the winds from the soundings are not used in any boundary layer parameter estimates.

If the dry-bulb or dew-point temperature is missing at some level, then an estimate for the missing temperature is made by linearly interpolating to the level in question. The data from the level immediately below and above the level in question are used. If the data that are required for the interpolation are also missing, then no interpolation is performed.

4.5 ONSITE PATHWAY

The ONSITE pathway provides a means of including data recorded during an observation program such as might be required for dispersion modeling for a facility. Such a program may utilize an instrumented tower (with data from several levels), a remote sensing device (such as lidar), and instrumentation at or near ground level (such as measuring fluxes). Much of this type of data can be used in AERMET to provide better estimates of the boundary layer parameters than using NWS data alone.

There are several keywords that are nearly identical to those found on the SURFACE and UPPERAIR pathways, and there are several keywords that are unique for this type of data. The presence of so many keywords may make the specification of site-specific data seem very complex. However, it can be almost as simple as for NWS files. The only additional statements that must be included for site-specific data are those required to describe the structure of the data and a minimum detectable wind speed. All other statements are optional and could be omitted.

4.5.1 Retrieving Archived Data - DATA

The file containing the site-specific data is specified on the DATA keyword. Unlike the SURFACE and UPPERAIR pathways, there is no standard format or content for site-specific data. Thus, only the file name is specified on this keyword. The syntax and type for the DATA keyword are:

Syntax:	DATA *data_filename*
Type:	Mandatory (Stage 1), Nonrepeatable

The *data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters.

4.5.1.1 Where is the EXTRACT keyword?

Unlike SURFACE and UPPERAIR data, site-specific data are not stored (archived) in any particular format. Therefore, the data are not "extracted" from an archive file, and there is no need for the EXTRACT keyword. The processing can begin with the quality assessment. Thus, the input file to the QA is defined on the DATA keyword.

4.5.2 <u>Defining the File Structure</u> - READ and FORMAT

The key to reading site-specific meteorological data correctly in AERMET is to define what data are present and the format of the data. This task is accomplished with the READ keyword, which defines the list and order of variables present on a data record, and the FORMAT keyword, which defines the format of that record. These two statements together are much like reading or writing data in a Fortran program (see, for example, Fig. 3.2). The syntax and type of these two keywords are:

Syntax:	READ *record_index osname*1 ... *osname*n
Type:	Mandatory (Stage 1), Repeatable, Reprocessed

Syntax:	FORMAT *record_index Fortran_format*
Type:	Mandatory (Stage 1), Repeatable, Reprocessed

Each READ keyword is paired with a corresponding FORMAT keyword through the *record_index* field. This index refers to one record of data for an observation period. The indices are numbered sequentially beginning with 1. There can be up to 40 variables on any one data record and up to 20 records per observation period.

The format of the site-specific data is reasonably flexible, but subject to the following restrictions:

(1) The data for one observation period can be spread across several records, but the records for one period must be contiguous;

(2) The same variables must appear for all observation periods;

(3) The date and time information for each observation must be on the first record of the period; these may occur in any order within the first record, and must be integer format;

(4) The variables on the READ keywords must be a subset of those listed in Appendix B, Tables B-3a and B-3b;

(5) Single-level variables must be read before any multi-level (e.g., tower) variables;

(6) The file must be ASCII and it must be in a form that can be read using Fortran FORMAT statements.

When specifying the multi-level variables, such as observations from an instrumented tower, the variable name is composed of a two-character prefix that identifies the atmospheric quantity and a two-character suffix that identifies the level. For example, height, temperature and wind speed from the first level would appear as HT01, TT01 and WS01 on the READ keyword, HT02, TT02, WS02 from the second level, and so on. The same variables do not have to appear on each record. For example, winds may appear at three levels but temperature only at two levels.

The *Fortran_format* is a character string that AERMET uses directly in the program. Hence, the string must comply with all the rules of Fortran for creating a format statement. The format must begin with an open parenthesis and end with a closing parenthesis. The list-directed format specifier (an asterisk, *) cannot be used because the parentheses are required and the string "**(*)**" is not recognized by AERMET and the compilers that created the executable code. Any book on standard Fortran can provide guidance on constructing a format statement.

Blanks in the format specification must be avoided because AERMET interprets blanks as field delimiters on the keywords. Blanks in the format specification will cause an error in processing the keyword.

Not all of the variables present in the site-specific data file need to be read. Any superfluous data can easily be skipped over using the X, T and / edit descriptors. However,

☞ **the same format used to read the original site-specific data file is also used to write the QA file**.

If some variables or entire lines of data are skipped, then the QA output file will contain corresponding blank fields and/or blank lines.

Once the variables and formats have been defined, the user does not need to specify them for any subsequent AERMET runs (e.g., for Stage 3 processing) as long as the information remains in the file header records. AERMET reprocesses these records whenever the data are used in subsequent processing, saving the user the time required to setup that portion of a runstream file and avoiding introducing errors on these two keywords.

4.5.3 Processing a Subset of the Data - XDATES

The amount of data processed can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be extracted. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Mandatory (Stage 1), Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to process and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces within the date group. The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

4.5.4 Identifying the Station - LOCATION

AERMET requires location information about the site where the measurements are taken. The LOCATION keyword specifies the station identifier, latitude and longitude, and a time adjustment factor. The syntax and type are:

Syntax:	LOCATION *site_id* *site_lat/long* *site_long/lat* [*tadjust*]
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is an eight character alphanumeric specifier that identifies the site. Since data are not extracted from archived data, this identifier is used only to identify the site in the output files (reports and from Stage 3).

The measurement site latitude and longitude can be entered in either order because AERMET distinguishes between the two by the suffix on each: an N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N". AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north and south and east and west. The site latitude and longitude for the ONSITE pathway are not used for any purpose at this time. They are simply another way to identify the site being processed.

The final parameter for this keyword, *tadjust*, is optional and is an adjustment factor to convert the time of each observation in the input data file from the reported time to local standard time. The adjustment factor is subtracted from the reported hour. The default value for *tadjust* is zero. Since there is no standard format for site-specific data, the time reported could be relative to any time frame. For example, one time frame the user should verify is if the data are reported in local <u>daylight</u> time. If this is the case, then *tadjust* could be specified as 1 to return the data to local standard time, assuming that daylight time was used throughout the entire data period.

4.5.5 How good are the data? - QAOUT

One purpose of AERMET is to contribute to the quality assurance process by identifying data that are out of range or suspect such that the user can determine appropriate steps to accept, modify, or reject the data. The quality assessment (QA) is performed by including the QAOUT keyword in a runstream. This keyword is also used to specify the input file name to Stage 2. The syntax and type for the QAOUT keyword are:

Syntax:	QAOUT *qa_output_filename*
Type:	Optional (Stage 1), Nonrepeatable Mandatory (Stage 2), Nonrepeatable

The *qa_output_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters. For one year of data with three levels and six variables (including the heights), the size of the output file is approximately 1.7 Mb.

Quality assessment is an optional process and the user does not have to perform a QA prior to merging the on-site data. However, this step is recommended to identify any possible problems with the data that are used to derive the boundary layer parameters.

Presently, AERMET's capabilities in this area are limited to verifying the values of the site-specific data are not outside a range of acceptable values and keeping track of the number of missing values. These checks operate one observation period at a time, i.e., variations over a period of time are not checked.

Site-specific data may be reported more frequently than once per hour (see the OBS/HOUR keyword discussed below). For observations more frequent than once per hour, the QA procedures operate on the subhourly data. There is no QA on the one-hour averaged data.

When a quality assessment is performed on the site-specific data, several of the variables are automatically tracked (audited) and included in a summary of the QA process. These variables are: temperature, wind speed and wind direction. The value of each variable at each level is compared to a missing value indicator and if the value is not missing, then the value is compared to an upper and lower bound that define the range of acceptable values. Each time a value is missing or violates one of the bounds, a message is written to the message file defined on the MESSAGES keyword, which identifies the variable, the violation, and data and time of occurrence. The number of times the variable is missing, exceeds the upper bound and exceeds the lower bound is tallied and reported in the summary file defined by the REPORT keyword.

In the current version of AERMET there are no provisions for automatically replacing missing values or adjusting values that are outside the range of acceptable values. It is up to the user to review the QA summary information and, using sound meteorological principles and any regulatory guidance, either replace the value in question or leave it alone.

There are default upper and lower bounds in AERMET, as well as a default missing value indicator for each variable. These values can be changed by the user through the use of the RANGE keyword, as described below. The user can QA additional variables by using the AUDIT keyword.

4.5.6 Adding Site-specific Variables to the QA - AUDIT

There are only three site-specific variables that are tracked by default during a QA. The user can track additional variables for a particular AERMET run by specifying the variable name on an AUDIT keyword. The syntax and type for this keyword are:

Syntax:	AUDIT *osname*1 ... *osname*n
Type:	Optional (Stage 1), Repeatable

where *osname*1, ..., *osname*n are the upper air variable names as defined in Table B-3. For the multi-level variables (e.g., temperature) only the two leading alphabetic characters can be specified (e.g., TT), otherwise AERMET will terminate with an error. Every level where the variable appears will be QA'd. As many variable names can be specified on a single keyword that will fit within the 80-character limitation of a keyword. Since this keyword is repeatable, more than one AUDIT keyword can be used to define additional variables.

4.5.7 Changing the Default Values for the QA - RANGE

The user can modify the upper and lower bound limits for the QA if the values are not appropriate for the data. The missing value indicator can be changed as well. These changes are accomplished using the RANGE keyword. The syntax and type for the RANGE keyword are:

Syntax:	RANGE *osname* *lower_bound* <[=] *upper_bound* *missing_indicator*
Type:	Optional (Stage 1), Repeatable, Reprocessed

where *osname* is the site-specific variable as defined in Table B-3, *lower_bound* and *upper_bound* are the new lower and upper bounds to be used in the QA, and *missing_indicator* is a new missing value code. The special symbol "<" and the optional "=" indicate whether to exclude (<) or include (<=) the lower and upper bound values in the QA, i.e., exclude or include the endpoints of the acceptable range of values. All parameters must be specified for this keyword even if a parameter is not changing; if a parameter is not changing, the default value should be specified. For the multi-level variables (e.g., wind speed and temperature), only the first two characters should be specified (e.g., WS and TT).

Unlike data for the SURFACE and UPPERAIR pathways, the site-specific data are written to the output file as real and integer values without multipliers because of the variety of data and user-defined formats. The exceptions to this rule are the surface variables shared with the SURFACE pathway.

4.5.8 Reducing the Number of QA Messages - NO_MISSING

Every time a bound is violated or a value is missing, a message is written to the message file (defined on the MESSAGES keyword). If a variable that is tracked is missing most of the time, the message file could become very large. To reduce the number of missing value messages and the size of the message file, the NO_MISSING keyword can be included for QA. The syntax and type are:

Syntax:	NO_MISSING *osname*1 ... *osname*N
Type:	Optional (Stage 1), Repeatable

where *osname*1, ..., *osname*N are the variable names of the weather variables to omit from the message file. The missing values are not tallied or reported in the summary file when this keyword is used.

4.5.9 An Alternate Specification of Measurement Heights - OSHEIGHTS

The measurement heights for the multi-level profile data may or may not appear explicitly as one of the variables in the data file. These heights (in meters) can be entered on a OSHEIGHTS statement in order from lowest to highest. The syntax and type for this keyword are:

Syntax:	OSHEIGHTS *height*1 ... *height*n
Type:	Optional if height information is in data; otherwise mandatory (Stage 1), Repeatable, Reprocessed

This statement can also be used to override the height variables that may be present in the data file. For example, if the heights in the data file are 10.0, 50.0 and 100.0, but the user knows that the heights are really 9.0, 50.0 and 100.0, rather than modify the data file, the OSHEIGHTS keyword can be used to rectify the problem.

4.5.10 Temperature Differences - DELTA_TEMP

In addition to measuring ambient temperature directly, an site-specific data program may measure differences in temperature. These measurements can be either between the levels where the ambient temperature is measured or independently of these levels. Temperature difference near the surface can be used to infer sensible heat flux. Measured temperature differences are not the same as the ambient temperature difference between two levels. A true temperature difference utilizes an instrument, such as a thermocouple, that couples two levels of data, whereas ambient temperature at two levels most likely is measured by two independent instruments, as with wind vanes.

The ONSITE data pathway has provisions for up to three temperature differences, which are defined through the three variables DT01, DT02 and DT03 (see table B-3). The heights that define the temperature difference cannot be entered directly through the READ and FORMAT keywords. The special keyword DELTA_TEMP defines the two levels that comprise the temperature difference. The syntax and type are:

Syntax:	DELTA_TEMP *index lower_height upper_height*
Type:	Optional (Stage 1), Repeatable, Reprocessed

Each statement includes an index that corresponds to the temperature difference represented by the *lower_* and *upper_heights*. The *index* can range from one to three.

At present, none of the processing options in Stage 3 utilizes temperature difference. Methods may be incorporated in future versions of AERMET that require these values, and the structure for processing such data will already exist.

4.5.11 Threshold Wind Speeds - THRESHOLD

The minimum wind speed required to detect air flow varies from anemometer to anemometer. For NWS data, this speed is assumed to be 1 m/s. However, site-specific measurement programs frequently use instruments that can detect speeds below this value. The user must specify the minimum detectable (threshold) wind speed of the site-specific anemometer. The THRESHOLD keyword is used for this purpose. The syntax and type for this keyword are:

Syntax:	THRESHOLD *threshold_wind_speed*
Type:	Mandatory (Stage 1), Nonrepeatable, Reprocessed

There is no default value;

☞ **the user must include this keyword when site-specific data are processed.**

The threshold can be no greater than 1.0 ms^{-1}. A value greater than 1.0 generates an error condition and AERMET does not process any data. For threshold values above 0.5 ms^{-1}, AERMET writes a warning message.

AERMET also imposes a minimum allowable wind speed for defining the wind speed to use in estimating the boundary layer parameters. This minimum is independent of the threshold wind speed and is defined as $2^{1/2} * \sigma_{vmin}$, where $\sigma_{vmin} = 0.2$ m s^{-1}.

4.5.12 Multiple Observation Periods for Each Hour - OBS/HOUR

Site-specific data may be reported more frequently than once per hour. If the data include more than one equally-spaced observation period each hour, the keyword OBS/HOUR is used to specify the number of observations that AERMET should expect each hour. AERMET currently allows up to 12 observation periods per hour (i.e., every 5 minutes) and will calculate the average over all periods within the hour to produce an hourly average. At least half the observations for a variable must not be missing for AERMET to compute the average, otherwise the value for the hour is set to missing. A discussion on how the average is computed for each variable is in Section 5.2. If there is one observation period per hour, this keyword is optional. The syntax and type for this keyword are:

Syntax:	OBS/HOUR *n_obs*
Type:	Mandatory for data with more than 1 observation per hour (Stage 1), Nonrepeatable

All variables specified on the READ keywords must be reported at the same number of observations per hour, e.g., one variable cannot be reported once per hour and the remaining variables reported four times per hour.

Each hour of data must contain the same number of observation periods per hour. For example, if the user specifies 4 OBS/HOUR, but there are only two observation periods for one hour in the middle of the file, AERMET will not detect this condition and will not correctly compute the hourly averagesfor all subsequent hours.

4.6 MERGE PATHWAY

This pathway is referred to as Stage 2 processing, which involves combining the different sources of data into one file composed of blocks of 24-hour data. This is an intermediate, but necessary, step between extracting and QA'ing archived data and estimating boundary layer parameters. As such, there are only two keywords related directly to this pathway.

4.6.1 The Output File - OUTPUT

As the data are combined/merged together in 24-hour blocks, the result is written to an ASCII output file. The file is specified on the OUTPUT keyword. The syntax and type for OUTPUT are:

Syntax:	OUTPUT *merged_data_filename*
Type:	Mandatory, Nonrepeatable

The *merged_data_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters.

The input data are provided by the three data pathways through the QAOUT keyword when such data are available. For example, if there are no site-specific data to merge, then only the QAOUT keywords for the SURFACE and UPPERAIR pathways are required.

This file can be very large. If all three data types are merged and there are six variables at three levels for the onsite data, then the output file will be about 6 Mb. If only NWS data are merged, then the output file will be about 3.2 Mb.

4.6.2 Merging a Subset of the Data - XDATES

As with the other data pathways, the amount of data merged can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be merged. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Optional, Nonrepeatable

YB, *MB* and *DB* are the beginning year, month and day, respectively, of the data to extract and *YE*, *ME*, and *DE* are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces within a date group. The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month.

The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

If the XDATES keyword is omitted, then the preprocessor searches all the input files to this stage and determines the earliest date in the files. AERMET then merges the data beginning with this date and continuing for 367 days even if all the data are exhausted in the input files.

4.7 METPREP PATHWAY

This pathway is also referred to as Stage 3. It is the heart of the AERMET preprocessor, where the boundary layer parameters are estimated for use by dispersion models. The processing is the third and final step in the sequence of steps that began with extracting data from archived data files. Unlike the processing up to this point, which was performed with one executable, this stage is a separate executable program.

Several of the keywords seen on the previous pathways are also used on this pathway in a nearly identical manner.

4.7.1 The Input Data File - DATA

Like all the previous stages, this stage requires input data. The data file generated by the Stage 2 processing - merging data - is the required file and is defined with the DATA keyword. The syntax and type are:

Syntax:	DATA *merged_data_filename*
Type:	Mandatory, Nonrepeatable

The *merged_data_filename*, which is an ASCII file, must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters.

4.7.2 Choosing a Dispersion Model - MODEL

Although AERMET currently only estimates parameters for the AERMOD dispersion model, it is designed with the capability to estimate parameters for other dispersion models. The MODEL keyword directs AERMET for which model to process the data. The syntax and type are:

Syntax:	MODEL *model_name*
Type:	Optional, Nonrepeatable

where *model_name* identifies the dispersion model. The AERMOD model is the default model, making this keyword optional.

4.7.3 Identifying the Site - LOCATION

AERMET requires information regarding the location of the site for which the data are being prepared. The LOCATION keyword is identical in all respects to its usage on other pathways: the site identifier, latitude and longitude, and a time adjustment factor. The syntax and type are:

Syntax:	LOCATION *site_id* *source_lat/long* *source_long/lat* [*tadjust*]
Type:	Mandatory, Nonrepeatable
Order:	Latitude (lat) and longitude (long) can appear in either order

The *site_id* is an eight character alphanumeric specifier that identifies the site. This field is simply a means to identify the site and is not used otherwise.

Unlike the SURFACE, UPPERAIR and ONSITE pathways, the latitude (*lat*) and longitude (*long*) on the METPREP pathway is very important. These coordinates should reflect the location of the source, i.e., the location where the dispersion model is to be applied. These coordinates are used to compute sunrise/sunset and solar elevation, which are required to estimate the surface fluxes and mixing heights. It is important to accurately identify the location of the source. Latitude and longitude can be entered in either order because AERMET distinguishes between the two by the suffix on each: an N or S with the latitude and W or E with the longitude. For example, "38.4N 81.9W" would be interpreted the same as "81.9W 38.4N". AERMET cannot use, nor does it recognize, "+" or "-" to discriminate between north and south and east and west.

The final parameter for this keyword, *tadjust*, is required and is an adjustment factor to convert the time of each upper air sounding in the input data file from local standard time back to Greenwich Mean Time to locate the 12Z sounding. The value of this parameter should be identical to the value entered on the UPPERAIR pathway when the data were extracted and, like the value for the UPPERAIR pathway, it is entered as a positive number.

A word of caution is in order at this point. The NWS has modified the method of reporting time in upper air sounding data. Prior to about 1990, the 00Z and 12Z soundings were reported with a time of 0000 and 1200, rather than the time the sounding was released, which was generally one hour earlier. Current practice is to report the hour of the actual release time. For example, a rawinsonde launched at 1100 GMT (0500 Eastern standard time) is reported as '11' in the archive file rather than '12' as it would have been reported in the past. This change has no affect on Stage 1 and Stage 2 processing but could potentially cause a problem in Stage 3 since AERMET looks in a 3-hour window of time to locate the 1200 GMT sounding (i.e., 1100 - 1300). If the zone conversion was specified correctly but the preprocessor fails to locate a morning sounding during Stage 3 processing, it is possibly due to a launch time outside the 1100-1300 GMT window. For example, the sounding times at North Platte, NE in July - August 1956 were reported with times of 0300 and 1500 GMT. When this situation occurs the convective mixing heights cannot be computed for the entire day and a message is written to the message file. If the user encounters this message, then either this situation occurred or the 12Z sounding is missing for that day. The upper air data for that day should be reviewed to determine if the data actually are missing or the sounding time is outside the search window (e.g., 1400 GMT). There are no quick corrective actions for a launch outside the search window. One action is to extract the data again using the correct zone conversion. If it is not possible to extract the data, another possible action is to edit the QA'd output file and force the times for the morning sounding to correspond to 12Z; e.g., if the launch was reported at 1400 GMT for a station in the eastern time zone (0900 LST), then editing the time to 0800 LST will allow AERMET to locate the sounding when the time zone conversion (5 in this example) is added to the time. An action that one might be tempted to make is to use an incorrect conversion time in the Stage 3 runstream; e.g., specify the factor as a 4 rather than a 5 for the example above. This action has undesirable consequences: the convective and stable periods in the Stage 3 output file of boundary layer parameters will be offset by the difference between the true zone conversion (5) and the incorrect zone conversion (4), resulting in unrealistic boundary layer parameters

To estimate the convective mixing heights, AERMET requires an early morning sounding each day. The search for the 1200 GMT sounding precludes using this version of AERMET in regions outside the western hemisphere, e.g., central Europe and Asia where the 12)) GMT sounding is in the afternoon.

4.7.4 Instrumentation Heights for NWS Data - NWS_HGT

When various parameters are computed for the dispersion models, the height of the instruments is usually required. With site-specific meteorological data, the heights of the measurements are generally available and entered through the READ or OSHEIGHTS keywords on the ONSITE pathway. If there are no site-specific data, or for isolated hours when there are site-specific data, then NWS data may be substituted for the computations. However, instrument height is not one of the reported parameters. The NWS_HGT keyword is used to provide this information. The syntax and type are:

Syntax:	NWS_HGT *variable_name* *instrument_height*
Type:	Mandatory, Repeatable

The *variable_name* specifies which meteorological instrument is being referenced and is followed by the *instrument_height* in the appropriate units. Currently, there is only one variable name: WIND. Typically, the height of the wind instrument (anemometer) is about 20 feet (6.7 meters) or 30 feet (9.1 meters), but could be any height. The former has been the standard height for many years at NWS sites. More recently, measurements at NWS sites have been raised to the latter height. The *Local Climatological Data Annual Summaries* available from NCDC contain a historical record of instrumentation sites and heights for the stations in the five volume set. The user should consult a reference such as the Annual Summaries prior to running Stage 3 to obtain the correct height to use with this keyword. AERMET requires the anemometer height in meters.

4.7.5 Processing a Subset of the Merged Data - XDATES

Like all previous pathways, the amount of data processed can be limited by using the XDATES keyword to specify the beginning and ending dates of the data to be merged. The syntax and type are:

Syntax:	XDATES *YB/MB/DB* [TO] *YE/ME/DE*
Type:	Optional, Nonrepeatable

YB, MB and DB are the beginning year, month and day, respectively, of the data to extract and YE, ME, and DE are the ending year month and day, respectively. The "/" is required between each field and there cannot be any spaces within the date group. The year is entered as a two-digit integer (e.g., 1992 is entered as 92). The month is a one- or two-digit integer corresponding to the month of the year and the day is the one- or two-digit day of the month. The word "TO" is optional and only serves to make the statement a little more readable. It is ignored by AERMET when this keyword is processed.

If the XDATES keyword is omitted, then the AERMET processes all the data in the input file specified on the DATA keyword.

4.7.6 Processing Options - METHOD

The METHOD keyword is used to define processing methods for the input data. This keyword requires a secondary keyword (*process*) to identify the particular meteorological variables that are affected and the option (*parameter*) to use. The syntax and type are:

Syntax:	METHOD *process* *parameter*
Type:	Optional, Repeatable

There are two secondary keywords for the METHOD keyword in AERMET: WIND_DIR, which affects the way in which the reference wind direction is handled for NWS data, and REFLEVEL, which directs AERMET to use or not use NWS data if site-specific data are missing.

The parameter associated with the WIND_DIR secondary keyword can be one of two values: RANDOM or NORAND (default). National Weather Service wind directions are reported to the nearest 10° (e.g., a direction of 164° would be reported as 16). In PCRAMMET, a first-generation meteorological preprocessor used for models such as the Industrial Source Complex Short Term (ISCST3) model, the NWS wind directions are adjusted to yield a direction to the nearest degree. This procedure continues in AERMET, and is accomplished by adding the parameter RANDOM after the secondary keyword.

Randomization is accomplished by using a single-digit random number, with a separate random number predefined for each hour of the year. This array of numbers is static and is the EPA standard set of random numbers used to randomize wind directions. The random number is added to the wind direction (which is first multiplied by 10) and 4 is subtracted from the result to yield a direction to the nearest degree. The array of random numbers is internal to AERMET; therefore, a separate file of these standard random numbers is not necessary.

If the user does not want to randomize the wind direction, then this keyword can be omitted, i.e., the default is to not randomize the wind direction. However, if the user wants a reminder as to how the data were processed, the NORAND parameter can be specified.

This keyword has no effect when site-specific data are available for the hour. It is assumed that the site-specific wind direction is reported to the nearest degree and does not need randomizing.

The other secondary keyword is REFLEVEL. The only valid parameter is SUBNWS which directs AERMET to substitute NWS data in the computations in the event site-specific data are missing for the hour. If there are no site-specific data in the data base, i.e., only NWS hourly observations and upper air soundings were merged, this secondary keyword becomes mandatory because, if it is omitted, AERMET detects this condition (i.e., no site-specific data and do not substitute NWS data) as an error and will not process any data. If there are site-specific data in the data base, but some of the variables required for the computations are missing, then this parameter directs AERMET to SUBstitute NWS data to estimate the boundary layer parameters. Also, if the site-specific profiles of wind and/or temperature are missing for an hour, this parameter directs AERMET to use NWS data to create a single-level profile of wind and/or temperature.

4.7.7 Surface Characteristics - FREQ_SECT, SECTOR, and SITE_CHAR

Surface conditions at the measurement site, referred to as the surface characteristics, influence boundary layer parameter estimates. Obstacles to the wind flow, the amount of moisture at the surface, and reflectivity of the surface all affect the estimates. These influences are quantified through the surface albedo, Bowen ratio and roughness length (z_0), and are defined for AERMET through the three keywords FREQ_SECT, SECTOR and SITE_CHAR. These three keywords must appear together in a runstream file.

The FREQ_SECT keyword defines how often these characteristics change (the *frequency*), or alternatively, the period of time over which these characteristics remain constant, and the number of nonoverlapping sectors into which the 360°-compass is divided (*number_of_sectors*).

☞ **This keyword can appear only once and must appear before the SECTOR and SITE_CHAR keywords**.

The syntax and type are:

Syntax:	FREQ_SECT *frequency number_of_sectors*
Type:	Mandatory (Stage 3), Nonrepeatable, Reprocessed
Order:	This keyword must appear before SECTOR and SITE_CHAR

The *frequency* can be ANNUAL, SEASONAL or MONTHLY, corresponding to 1, 4, or 12 periods, respectively. ANNUAL and MONTHLY are straightforward: the site characteristics are the same for all months of the year, or the site characteristics vary from month to month, respectively. When SEASONAL is specified, then the site characteristics are distributed by month as follows:

Season #	Season	Months
1	Winter	December, January, February
2	Spring	March, April, May
3	Summer	June, July, August
4	Autumn	September, October, November

The number before the season represents the *frequency-index* that is specified for that season on the SITE_CHAR keyword.

A minimum of 1 and a maximum of 12 can be specified for the *number_of_sectors*. If more than 12 sectors are required, then the user will have to modify the parameter NWDS in MASTER.INC and recompile and relink AERMET (which is discussed in Section 6).

A SECTOR statement defines the beginning and ending wind direction sector for which the surface characteristics apply. The syntax and type of this keyword are:

Syntax:	SECTOR *sector_index beginning_direction ending_direction*
Type:	Mandatory (Stage 3), Repeatable, Reprocessed

One sector is defined per keyword, with the *sector_index* linking a specific sector to a set of site characteristics. The sectors are defined clockwise, they must cover the full circle, and these must be defined so that the end of one sector corresponds to the beginning of another. The *beginning_direction* is considered part of the sector, while the *ending_direction* is excluded from the sector. The directions reference the direction from which the wind is blowing. A sector can cross through north (e.g., 345 - 15) or can start and stop at north (e.g., 0 - 30 and 270 - 360). AERMET will verify that the entire 360° circle is covered. See Sections 3.1 and 5.4.2 for additional discussions on defining the wind direction sector and the associated surface characteristics.

The site characteristics are specified on SITE_CHAR keywords, with one statement for each combination of time period and wind sector. The syntax and type for this keyword are:

Syntax:	SITE_CHAR *frequency_index sector_index albedo Bowen roughness*
Type:	Mandatory (Stage 3), Repeatable, Reprocessed

The *frequency_index* varies from one to the number of time periods corresponding to the frequency defined on the FREQ_SECT keyword. The *sector_index* varies from one to the number of sectors defined on the FREQ_SECT keyword. These indices are followed by the albedo, Bowen ratio and roughness length for the frequency/sector combination. If the maximum frequency (MONTHLY) and number of sectors were defined, then it would require 144 (12 frequencies and 12 sectors) SITE_CHAR statements to completely define the site characteristics.

The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. Typical values range from 0.1 for thick deciduous forests to 0.90 for fresh snow. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of the sensible heat flux to the latent heat flux and is used for determining planetary boundary layer parameters for convective conditions. While the diurnal variation of the Bowen ratio may be significant, the Bowen ratio usually attains a fairly constant value during the day. Midday values of the Bowen ratio range from 0.1 over water to 10.0 over desert. The surface roughness length is related to the height of obstacles to the wind flow and is, in principle, the height at which the mean horizontal wind speed is zero. Values range from less than 0.001 m over a calm water surface to 1 m or more over a forest or urban area.

Tables 4-1 - 4-3, from Paine (1987), provide some guidance on specifying these values by land use type and season. In these tables, the seasons do not correspond to a particular group of months, but more on latitude and the annual vegetative growth cycles. Spring refers to the period when vegetation is emerging or partially green and applies to the 1-2 months after the last killing frost. The term summer applies to the period when vegetation is lush. The term autumn refers to the period of the year when freezing conditions are common, deciduous trees are leafless, soils are bare after harvest, grasses are brown and no snow is present. Winter conditions apply to snow-covered surfaces and subfreezing temperatures. For example, March in the southern United States is spring, but it is still winter in much of New England. It is up to the user to determine how to apply this information.

TABLE 4-1

ALBEDO OF GROUND COVERS BY LAND-USE AND SEASON

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.12	0.10	0.14	0.20
Deciduous Forest	0.12	0.12	0.12	0.50
Coniferous Forest	0.12	0.12	0.12	0.35
Swamp	0.12	0.14	0.16	0.30
Cultivated Land	0.14	0.20	0.18	0.60
Grassland	0.18	0.18	0.20	0.60
Urban	0.14	0.16	0.18	0.35
Desert Shrubland	0.30	0.28	0.28	0.45

The Bowen ratio for winter in the next three tables depends on whether a snow cover is present continuously, intermittently or seldom. For seldom snow cover, the values between autumn and winter may be more applicable; for continuous snow cover, the values for winter are applicable. For bodies of water, it is assumed that the surface is frozen.

TABLE 4-2a

DAYTIME BOWEN RATIO BY LAND USE AND SEASON
DRY CONDITIONS

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	2.0
Deciduous Forest	1.5	0.6	2.0	2.0
Coniferous Forest	1.5	0.6	1.5	2.0
Swamp	0.2	0.2	0.2	2.0
Cultivated Land	1.0	1.5	2.0	2.0
Grassland	1.0	2.0	2.0	2.0
Urban	2.0	4.0	4.0	2.0
Desert Shrubland	5.0	6.0	10.0	10.0

TABLE 4-2b

DAYTIME BOWEN RATIO BY LAND-USE AND SEASON
AVERAGE MOISTURE CONDITIONS

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	1.5
Deciduous Forest	0.7	0.3	1.0	1.5
Coniferous Forest	0.7	0.3	0.8	1.5
Swamp	0.1	0.1	0.1	1.5
Cultivated Land	0.3	0.5	0.7	1.5
Grassland	0.4	0.8	1.0	1.5
Urban	1.0	2.0	2.0	1.5
Desert Shrubland	3.0	4.0	6.0	6.0

TABLE 4-2c

DAYTIME BOWEN RATIO BY LAND-USE AND SEASON
WET CONDITIONS

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.1	0.1	0.1	0.3
Deciduous Forest	0.3	0.2	0.4	0.5
Coniferous Forest	0.3	0.2	0.3	0.3
Swamp	0.1	0.1	0.1	0.5
Cultivated Land	0.2	0.3	0.4	0.5
Grassland	0.3	0.4	0.5	0.5
Urban	0.5	1.0	1.0	0.5
Desert Shrubland	1.0	1.5	2.0	2.0

TABLE 4-3

SURFACE ROUGHNESS LENGTH, IN METERS, BY LAND-USE AND SEASON

Land-Use	Spring	Summer	Autumn	Winter
Water (fresh and sea)	0.0001	0.0001	0.0001	0.0001
Deciduous Forest	1.00	1.30	0.80	0.50
Coniferous Forest	1.30	1.30	1.30	1.30
Swamp	0.20	0.20	0.20	0.05
Cultivated Land	0.03	0.20	0.05	0.01
Grassland	0.05	0.10	0.01	0.001
Urban	1.00	1.00	1.00	1.00
Desert Shrubland	0.30	0.30	0.30	0.15

An additional source of information for surface roughness length can be found in Stull (1988).

4.7.8 Output from Stage 3 - OUTPUT and PROFILE

AERMET Stage 3 processing creates two output files for the AERMOD dispersion model. The first of these files contains the boundary layer parameters and some of the data that went into computing these parameters. These parameters are stored in the file defined on the OUTPUT keyword, with the following syntax and type:

Syntax:	OUTPUT *parameter_filename*
Type:	Mandatory, Nonrepeatable

The *parameter_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters. For one year of data, the size of this file is approximately 1 Mb.

There is one record for each hour processed. These data are written with at least one space between each element, i.e., "free format". The exact format of this file is in Appendix C. The contents of this file are:

Year
Month (1 - 12)
Day (1 -31)
Julian day (1 - 366)
Hour (1 - 24)
Sensible heat flux, H (Watts/meter^2)
Surface friction velocity, u_* (meters/second)
Convective velocity scale, w_* (meters/second)
Vertical potential temperature gradient in the 500 m layer above the planetary boundary layer (K/meter)
Convective mixing height, z_{ic} (meters)
Mechanical mixing height, z_{im} (meters)
Monin-Obukhov length, L (meters)
Surface roughness length, z_0 (meters)
Bowen ratio, B_o
Albedo, $r(\phi)$
Wind speed (meters/second) used in estimating the boundary layer parameters
Direction (degrees) the wind is blowing from, corresponding to the wind speed
Height at which the wind above was measured (meters)
Temperature (degrees kelvin) used in estimating the boundary layer parameters

Height at which the temperature above was measured (meter)

A second file is written during Stage 3 - a file of profile (multi-level) data as identified on the PROFILE keyword. The syntax and type are:

Syntax:	PROFILE *profile_filename*
Type:	Mandatory, Nonrepeatable

The *profile_filename* must conform to the naming conventions appropriate to the computing platform. The maximum length of this file name is 48 characters.

There are one or more records for each hour processed. The data are written with at least one space between each element, i.e., the data are free format. The exact format of this file is in Appendix C. The contents of this file are:

Year
Month (1 - 12)
Day (1 -31)
Hour (1 - 24)
Measurement height (meters)
Top flag = 1, if this is the last (highest) level for this hour,
0, otherwise
Direction the wind is blowing from for the current level (degrees)
Wind speed for the current level (meters/second)
Temperature at the current level (celsius)
Standard deviation of the wind direction fluctuations, σ_θ (degrees)
Standard deviation of the vertical wind speed fluctuations, σ_w (meters/second)

The data in this latter file are the multi-level (e.g., tower) site-specific meteorological data if site-specific data are available. If there are no data for a particular variable for an hour, either at one or all levels, then the field is filled with a missing value indicator. Only the variables listed above are in this output file. Additional variables that may be specified on the ONSITE pathway (e.g., the standard deviation of one of the horizontal components of wind) are not written to this file.

AERMET was designed to be able to perform these dispersion parameter calculations with NWS data only, i.e., no site-specific data. In this case, the NWS winds and temperature are used to create a one-level "profile". The NWS data are also used in the event that all the variables at all levels for a given hour are missing. However, this substitution depends on the specification of the METHOD REFLEVEL keyword described in Section 4.7.6.

For one year of data with three levels of site-specific data, the size of this file is 1.5 Mb. If NWS data are used to create the one-level profile, the size of the file is reduced to 0.5 Mb.

SECTION 5

TECHNICAL NOTES

This section provides a technical description of the processing methods employed by AERMET. This includes quality assessment procedures beyond the simple check against upper and lower bounds, the averaging method used to produce hourly values when site-specific data contains more than one observation period each hour, and modifications that can be made to NWS upper air data. The section concludes with a discussion of the estimates of the boundary layer parameters written to the OUTPUT file.

5.1 QUALITY ASSESSMENT PROCEDURES

The main quality assessment procedures are similar for all types of data. Each variable is checked to see if it is missing (its value matches the missing value code), and if not missing, the value is checked to see if it is between the lower and upper bounds. Appendix B lists the variables for each type of data, their units, default bounds and missing value codes. A violation does not necessarily indicate an error in the data. For example, it could mean the bounds are not reasonable for a particular time of year or location. It is up to the user to determine if the reported violations constitute errors in the data.

For NWS hourly surface observations, several additional checks between variables are also performed. NWS surface data are checked for dew-point temperature exceeding dry-bulb temperature (DPTP > TMPD), and having a zero wind speed (WSPD = 0), indicating calm conditions, but a non-zero wind direction (WDIR), indicating non-calm conditions, or vice versa. The number of occurrences of calm wind conditions are also reported.

AERMET estimates the heights reported in the sounding using the hypsometric equation

$$z_2 = z_1 + [(R_d * T_v)/g] * \ln(p_1/p_2)$$

where z_1 and p_1 are the height and pressure at the lower level, z_2 and p_2 are the height and pressure at the upper level, R_d is the dry gas constant, T_v is the mean virtual temperature through the layer, and g is the gravitational acceleration. The recomputed height is compared to the reported height. If the difference exceeds 50 meters, then a message is written to the message file (defined on the MESSAGES keyword). If the surface height is missing, then this check is skipped.

NWS upper air sounding data contain data for multiple levels, so AERMET will examine the *gradient* of several variables within the sounding. AERMET checks four different between-level gradients. Each is expressed as the change over a 100-meter layer because the change per meter is usually very small. It is important to remember this distinction if the user needs to change the default lower or upper bounds. The parameter and associated variable name in AERMET and the default lower and upper bounds are shown in the table below.

Parameter	Variable name in AERMET	Default lower bound	Default upper bound
Ambient temperature gradient	UALR	-2.0 °C	+5.0 °C
Wind speed shear	UASS	0.0 ms^{-1}	| 5.0 ms^{-1} |
Wind direction shear	UADS	0.0 degrees	| 90.0 degrees |
Dew point temperature gradient	UADD	0.0 °C	2.0 °C

The vertical gradient of the wind velocity, the wind *shear*, is a vector quantity. In AERMET, the shear is computed separately for the *speed shear* (UASS) and *direction shear* (UADS). The wind speed shear is computed as the absolute difference in the speeds between adjacent levels. Since it is an absolute difference, it is always non-negative. The wind direction shear is also an absolute difference.

The vertical gradient of the dew point temperature, unlike the other gradients, is computed using three consecutive levels. An estimate of the dew point at each intermediate height is found using linear interpolation between the dew points for the adjacent upper and lower heights. The gradient of the dew point temperature is defined as the absolute difference between the estimated and the observed dew point temperature at this intermediate level divided by the difference between the upper and lower heights.

The QA on the gradients are summarized with the QA of the observed sounding data. Because there may be a variable number of levels in a sounding, and the heights of the levels may differ from sounding to sounding, the results are accumulated into ten height categories. These are defined as surface, 500 meter layers up to 4000 meters, and above 4000 meters. Thus the categories are: surface, 0 – 500, 500 – 1000, ..., 3500 – 4000, and 4000+, where each intermediate category includes the upper but not the lower height. (The "thickness" of the categories is controlled by the internal variable UAINC. This is specified in a DATA statement in MASTER.INC, and cannot be changed without also recompiling and relinking AERMET.)

Lapse rate and shear violations are tallied in the category containing the upper height, while those of the dew-point gradient are tallied in the height category of the middle (intermediate) point. In the absence of missing data and with N levels in a sounding, there should be $N-1$ lapse rate and shear calculations, and $N-2$ dew-point gradient calculations. All range violations and instances of missing values are reported in the MESSAGES file and summarized in the general report.

5.2 Site-specific DATA - AVERAGING SUBHOURLY VALUES

By default, AERMET assumes that there is one observation period per hour. However, the on-site data could contain several observation periods during each hour (AERMET allows up to 12). Since AERMET only computes the boundary layer parameters for one hour averages, AERMET converts the subhourly observations to an hourly average. The user must tell AERMET the number of observation periods per hour that are in the site-specific data through the use of the OBS/HOUR keyword. See Section 3.5.13 for a discussion on how to use this keyword. The site-specific meteorological guidance document (EPA, 1987) suggests at least half of this number must be present to calculate an average for the hour. AERMET follows this guidance and computes an average only when half or more of the subhourly values are not missing.

For most variables, the hourly value is computed as the arithmetic mean. However, the wind speed and direction are treated differently to differentiate between cases when values are missing and cases when values are present but below an instrument's threshold. This value is defined by the user through the mandatory THRESHOLD keyword. Wind speeds less than threshold are given a value of one-half the threshold wind speed and the wind direction is set to missing. The hourly wind speed is then computed as an arithmetic mean, while the hourly wind direction is computed according to the method given in Section 6.1 of the on-site meteorological guidance document (EPA, 1987) to properly account for the 0°-to-360° crossover.

To obtain a one-hour average of the standard deviation of the horizontal wind direction, σ_θ, the procedure outlined in the *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV* (EPA, 1989) is followed. This procedure accounts for both the standard deviation within each subhourly interval and the meander in the wind direction over the entire hour. The hourly average is given by

$$\sigma_\theta^2 = \frac{1}{n} \sum_{i=1}^{n} (\sigma_{\theta i}^2 + WD_i^2) - \overline{WD}^{\,2}$$

where $\sigma_{\theta i}$ is the standard deviation of the horizontal wind for period I, WD_i is the average wind direction for period I, $\overline{WD}$ is the average wind direction over all periods in the hour, and n is the number of subhourly periods specified on the OBS/HOUR keyword.

5.3 UPPER AIR DATA MODIFICATIONS

During the extraction of upper air soundings from the raw input DATA file, AERMET can check for possible errors and reduce the impact of strong gradients in each sounding. If the MODIFY keyword (Section 4.4.10) is included, the following modifications are performed:

- A mandatory level within 1 percent (with respect to pressure) of a significant level is deleted;
- For a non-zero wind direction with a corresponding zero wind speed, the wind direction is replaced with zero;
- Missing values of dry bulb and dew-point temperature are replaced by an interpolated value if the data for the levels immediately above and below are not missing;

There is no way to turn on individual actions. Either all the actions are performed or none of them are performed. Warning messages are written if the data are modified.

5.3.1 Mandatory Levels

If a mandatory sounding level is within one percent of a significant level (with respect to pressure) then the mandatory level is deleted, with little of information about the structure of the atmosphere. If the maximum number of levels of data were extracted (currently set at 30 and is defined in the variable UAML in UA1.INC), then a sounding may have fewer than the maximum number of levels because the deletion process takes place after the data in a sounding are extracted from the archived data file. AERMET does not attempt to read more levels after deleting a level.

5.3.2 Calm Wind Conditions

The wind speed and wind direction at each level are checked to insure that there are no levels with a zero wind speed and a non-zero wind direction. If one is found, the wind direction is set to zero to represent calm conditions.

5.3.3 Missing Dry Bulb and Dew-Point Temperatures

If the dry-bulb or dew-point temperature is missing at some level, then an estimate for the missing temperature is made by linearly interpolating to the level in question. The data from the level immediately below and above the level in question are used. If the data that are required for the interpolation are also missing, then no interpolation is performed.

5.4 BOUNDARY LAYER PARAMETER ESTIMATES IN STAGE 3

AERMOD uses several different boundary layer parameters to model how pollutants disperse in the atmosphere. Many of these parameters are not observed, but are estimated from other variables that are more easily measured. To make these estimates, observed near-surface wind and temperature (the 'reference' wind and temperature) and site-specific surface characteristics are required. The surface characteristics are discussed in detail in Sections 2 and 3, but because of the importance in estimating boundary layer parameters, they are reviewed below. First, however, is a discussion on the criteria for defining the reference wind and temperature.

5.4.1 Reference Wind and Temperature

If there are site-specific data in the meteorological input to Stage 3, then AERMET searches these data for near-surface wind and temperature with which to estimate the boundary layer parameters such as friction velocity and heat flux.

A valid reference wind is defined as the lowest level with a nonmissing wind speed and direction between $7 \cdot z_0$ and 100 meters (inclusive), where z_0 is the surface roughness length. If the only valid nonmissing wind speed is a calm wind, then the hour is treated as a calm and the reference level is the lowest level of nonmissing wind.

If there is no valid reference wind, then the lowest level is treated as the reference level and the reference wind is missing. However, if the option to substitute NWS data is specified in the runstream (see Section 4.7.6 for the keyword METHOD, secondary keyword REFLEVEL), then AERMET will substitute the NWS hourly wind speed observations for the reference wind speed and use the height specified with the keyword NWS_HGT (see Section 4.7.4) as the reference height. If NWS substitution is not specified, then the reference wind will be missing.

The selection of the reference temperature is independent of the selection of the reference wind. A valid reference temperature is defined as the lowest level with a nonmissing temperature between z_0 and 100 meters (inclusive). If there is no valid reference temperature in the site-specific data and the option to substitute NWS data is specified in the runstream, then AERMET will substitute the NWS hourly ambient temperature for the reference temperature.

In the absence of site-specific data, the METHOD keyword with the REFLEVEL secondary keyword must be specified for AERMET to utilize NWS wind and temperature data for the reference level data. NWS data currently are not subject to the criteria above for either wind or temperature.

5.4.2 Surface Characteristics

The atmospheric boundary layer is that region between the earth's surface and the overlying, free flowing (geostrophic) atmosphere. The fluxes of heat and momentum drive the growth and structure of this boundary layer. The depth of this layer, and the dispersion of pollutants within it, are influenced on a local scale by surface characteristics, such as the roughness of the underlying surface, the reflectivity of the surface (or albedo), and the amount of moisture available at the surface. From these input parameters and observed atmospheric variables, AERMET calculates several boundary layer parameters that are important in the evolution of the boundary layer, which, in turn, influences the dispersion of pollutants. These parameters include the surface friction velocity u_*, which is a measure of the vertical transport of horizontal momentum; the sensible heat flux H, which is the vertical transport of heat to/from the surface; the Monin-Obukhov length L, a stability parameter relating u_* and H; the daytime mixed layer height z_i and the nocturnal surface layer height h; and w_*, the convective velocity scale that combines z_i and H. These parameters all depend on the characteristics of the underlying surface.

Although very general default values exist in AERMET, the user should specify the albedo (r), which is the fraction of radiation reflected by the surface; the daytime Bowen ratio, B_o, which is the ratio of the sensible heat flux H to the heat flux used in evaporation λE; and the surface roughness length z_o, which is the height above the ground at which horizontal wind velocity is typically zero. These measures depend on land-use type (e.g., urban area, deciduous/coniferous forest, cultivated land, calm waters) and vary with the seasons (See Tables 3-1 to 3-3) and wind direction.

The user specifies these values on SITE_CHAR keyword statements for one, four or 12 (ANNUAL, SEASONAL, or MONTHLY) time periods per year, and 1 - 12 nonoverlapping, contiguous wind direction sectors that cover the full 360°. The user is referred to Sections 2.2.4, 3.1.3, and 4.7.7 for detailed discussions on these parameters.

5.4.2.1 <u>Choice of Sector-Dependent Surface Characteristics</u>

In defining sectors for surface characteristics, Irwin (1994) and EPA (2000) suggest that a user specify a sector no smaller than a 30-degree arc. The expected wind direction variability over the course of an hour, as well as the encroachment of characteristics from the adjacent sectors with travel time, make it hard to preserve the identity of a very narrow sector's characteristics. However, using a weighted average[3] of characteristics by surface area within a 30-degree sector makes it possible to have a unique portion of the surface significantly influence the properties of the sector that it occupies.

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[3]Weighting should be based on wind direction frequency, such as determined from a wind rose.

The length of the upwind fetch for defining the nature of the turbulent characteristics of the atmosphere at the source location has been defined as 3 kilometers in EPA's *Guideline on Air Quality Models*, which is published as Appendix W to 40 CFR Part 51 (as revised), for the purpose of defining urban versus rural dispersion characteristics. This specification results from a paper by Irwin (1978), which also cites a study by Högström and Högström (1978). The basic premise is that when the wind blows over an area with a change in its surface characteristics, a new "boundary layer" with the turbulent characteristics of the underlying surface develops and deepens along the wind direction. Högström and Högström present tabular results for the boundary layer growth as a function of roughness length in rural areas. Irwin (1978) noted that the region of enhanced turbulence with a depth of 400 meters was reported by Shea and Auer (1978) for St. Louis, and curves based on the Högström and Högström data indicate that a 3-km fetch would attain this boundary layer height. The resulting 3-km fetch was also adopted by METPRO (Paine, 1987), the CTDMPLUS meteorological pre-processor for its definition of sector-specific surface characteristics.

For a surface with a large roughness, however, the rate of the boundary layer growth as defined by Högström and Högström (1978) could be sufficiently rapid so as to grow to a depth of 400 meters within 1 kilometer downwind. In the case of a lower boundary layer depth, such as 100 meters, the Högströms calculate that the distance needed to attain an urban-influenced boundary height of just 100 meters with a surface roughness ranging from 0.5 to 1.5 meters is only about 250 meters for unstable (convective) conditions, 700 meters for neutral conditions, and 1330 meters for slightly stable conditions.

For AERMET applications, an upwind fetch distance of 3 kilometers is recommended for defining user-specified values such as albedo, Bowen ratio, and surface roughness. In each sector, it is likely that a mixture of land use is present, and the resulting user input should be a weighted average of the values selected for each land use type. For urban areas or areas with a very large roughness length, consideration can be given for a smaller upwind fetch distance for defining the user-specified surface characteristics. The actual fetch length selected would be a function of the expected plume height, the roughness length, and any urban heat flux that would tend to minimize the presence of stable conditions in the surface layer. Högström and Högström (1978) can be used as guidance in these cases.

5.4.3 Estimates for the Unstable Atmosphere

As defined in AERMET, the atmosphere is unstable if the flux of sensible heat is upward at the surface, and the time of day is approximately between sunrise and sunset. During daytime convective conditions, the surface of the earth is heated, resulting in an upward transport of heat. Hourly estimates of this heat flux are required to estimate the daytime mixed layer height. The estimates here follow the development of Holtslag and van Ulden (1983). Beginning with the surface energy balance, the sensible heat flux is determined hour-by-hour from the net radiation and Bowen ratio. AERMET first looks for net radiation (from the site-specific data) and uses it if found. If there is no net radiation, then AERMET looks for solar radiation (again from the site-specific data) and uses it, temperature, and opaque cloud cover (from the NWS) to estimate net radiation. If there is no solar radiation, then it is estimated as described below from cloud cover and surface temperature (using site-specific observations if available, NWS data if not), Bowen ratio, and albedo. Once the heat flux is computed, u_* and L are determined through an iterative procedure using surface layer similarity. While u_* and L change with each iteration, the hourly heat flux remains fixed.

A simple equation that expresses the energy balance at the earth's surface for rural applications is:

$$R_n = H + \lambda E + F_G \tag{5.1}$$

where R_n is the net radiation, λE is the latent heat flux, and F_G is the flux of heat into the ground. Following Holtslag and van Ulden (1983), $F_G = 0.1\ R_n$. Using this estimate for F_G and the Bowen ratio ($B_o = H/\lambda E$) yields the following expression for H:

$$H = 0.9 R_n \ / \ (1 + (1 \ / \ B_o)) \tag{5.2}$$

Net radiation R_n can either be an observed quantity from site-specific data (variable

NRAD) or it can be estimated from the total incoming solar radiation, R (variable INSO), as follows:

$$R_n = (1 - r(\phi))R - I_N \tag{5.3}$$

where $r(\phi)$ is the surface albedo as a function of solar elevation angle (ϕ), and I_N is the net long-wave radiation at the earth's surface.

In the general case in which clouds are present, R is computed using the following estimate from Kasten and Czeplak (1980)

$$R = R_0 (1 + b_1 n^{b_2}) \tag{5.4}$$

where R_0 is the incoming solar radiation at ground level for clear skies, and n is the fractional opaque cloud cover (variable TSKC). The empirical coefficients b_1 and b_2 are assigned the values of -0.75 and 3.4, respectively (from Holtslag and van Ulden, 1983). If cloud cover and observed net radiation are missing for a particular hour, no further calculations can be made for that hour. A warning message is written in this case.

The incoming solar radiation for clear skies R_0 is given by

$$R_0 = a_1 \sin\phi + a_2 \tag{5.5}$$

where ϕ is the solar elevation angle, a_1 = 990 W m^{-2} and a_2 = -30 W m^{-2}. The constants a_1 and a_2 account for attenuation of the short wave radiation by water vapor and dust in the atmosphere. The values used by AERMET are appropriate for mid-latitudes (Holtslag and van Ulden (1983)).

Substituting Eqs. 5.4 and 5.5 into 5.3 and parameterizing the net long-wave radiation as a function of temperature (T) and cloud cover (n), Holtslag and van Ulden (1983) estimate the net radiation as:

$$R_n = \frac{(1 - r(\phi))R + c_1 T^6 - \sigma_{SB} T^4 + c_2 n}{1 + c_3} \tag{5.6}$$

where σ_{SB} = 5.67 × 10^{-8} W m^{-2} K^{-4} is the Stefan-Boltzmann constant and the other empirical constants are as follows: c_1 = 5.31 × 10^{-13} W m^{-2} K^{-6}, c_2 = 60 W m^{-2}, c_3 = 0.12

The surface albedo supplied by the user should be for solar elevation angles above 30°, for which the albedo is relatively constant. However, the albedo increases for lower angles (Coulson and Reynolds (1971) and Iqbal (1983)). An empirical expression for the albedo as a function of solar elevation angle is given by

$$r(\phi) = r' + (1 - r')\, e^{a\phi + b} \tag{5.7}$$

(Paine, 1987) where r' is the albedo for the sun on the meridian as entered by the user as a site-specific surface characteristic, ϕ is the solar elevation angle, $a = -0.1$, and $b = -0.5\,(1 - r')^2$.

With an estimate of the heat flux, AERMET next estimates the surface friction velocity u_* and the Monin-Obukhov length L for the convective boundary layer (CBL) through an iterative procedure. (This technique used is similar to that used in the METPRO meteorological preprocessor (Paine (1987).) The two equations for u_* and L used in the iteration algorithm are:

$$u_* = \frac{k\,u}{\ln(z_{ref}/z_o) - \Psi_m(z_{ref}/L) + \Psi_m(z_0/L)} \tag{5.8}$$

and

$$L = -\frac{\rho\, c_p\, T\, u_*^3}{k\, g\, H} \tag{5.9}$$

where

k is the von Karman constant (0.4),

u is the reference height wind speed (meters/second),

z_{ref} is the wind speed and direction reference height (as discussed in Section 3.1.3),

z_o is the surface roughness length (meters),

ρ is the density of dry air (kilograms/cubic meter),

c_p is the specific heat capacity of air (Joules/kilogram/Kelvin),

T is ambient temperature (Kelvin), and

g is the acceleration due to gravity (meters/second/second).

The Ψ terms are given by:

$$\Psi_m(z_{ref}/L) = 2\ln\left(\frac{1+\mu}{2}\right) + \ln\left(\frac{1+\mu^2}{2}\right) - 2\tan^{-1}(\mu) + \pi/2 \qquad (5.10)$$

$$\Psi_m(z_o/L) = 2\ln\left(\frac{1+\mu_o}{2}\right) + \ln\left(\frac{1+\mu_o^2}{2}\right) - 2\tan^{-1}(\mu_o) + \pi/2 \qquad (5.11)$$

and

$$\mu = (1 - 16 z_{ref} / L)^{1/4} \qquad (5.12)$$

$$\mu_o = (1 - 16 z_o / L)^{1/4} \qquad (5.13)$$

This procedure requires an initial guess for u_*, which is found by initially setting the Ψ terms to zero. The iteration continues until consecutive values of L differ by 1% or less.

The estimate of the convectively-generated (or convective) mixing height (z_{ic}) is based on the formulation by Carson (1973) and modified by Weil and Brower (1983). The Carson model is based on a one-dimensional (height) energy balance approach, in which the heat flux in the CBL at the surface, and entrained from the stable air aloft, leads to vertical mixing, a rise in the base of the elevated temperature inversion, and an increase of the energy of the boundary layer air. The original Carson model is based on an initial (early morning) potential temperature profile that is assumed to be linear with height. Weil and Brower (1983) extended Carson's model to an arbitrary initial temperature distribution with height and allowed for stress-induced mixing at top of the PBL. The latter can be important when the heat flux is small, e.g., in the early morning or on overcast days. In this version of AERMET, the stress-induced mixing at the top of the mixed layer is ignored. An operational advantage of the arbitrary temperature distribution is the ease of adapting it to initial profiles that are very irregular, as is sometimes found in early morning rawinsondes.

Weil and Brower find z_{ic} implicitly from the following equation:

$$z_{ic}\,\theta(z_{ic}) - \int_0^{z_{ic}} \theta(z)\,dz = (1 + 2A)\int_0^{t} \frac{H(t')}{\rho c_p}\,dt' \qquad (5.14)$$

where $\theta(z)$ is the initial potential temperature distribution (from the 12Z sounding) and the right-hand-side represents the cumulative heat flux input at $z = 0$, and A = 0.2 (Deardorff, 1980). AERMET restricts the growth of the convective mixing height to 4000 meters.

Once z_i is found, the turbulent velocity scale w_* can be found from the following definition:

$$w_* = (\, gHz_{ic} \,/\, \rho c_p T\,)^{1/3}\ . \qquad (5.15)$$

5.4.4 Estimates for the Stable Atmosphere

The stable boundary layer (SBL) calculations, based on an approach outlined by Venkatram (1980), are straight-forward and do not require an iterative process as is used in the CBL calculations. Estimates of u_* and θ_*, a temperature scale, are made from cloud cover, wind speed and temperature, which, in turn, provides an estimate of the heat flux. The Monin-Obukhov length then is computed directly from Eq. 5.9.

Using $H = -\rho\, c_p\, u_*\, \theta_*$ in Eq. 5.9 and

$$k \frac{u}{u_*} = \ln\left(\frac{z_{ref}}{z_0}\right) + \beta_m \frac{z_{ref}}{L}$$

the friction velocity is obtained from

$$u_* = C_D u/2 \ (1 + (\ 1 - (\ 2u_o \ / \ C_D^{1/2} u\ )^2\ )^{1/2}\ ) \tag{5.16}$$

where C_D is the neutral drag coefficient given by

$$C_D = \frac{k}{\ln(z_{ref} \ / \ z_o\ )}\ , \tag{5.17}$$

u_o is

$$u_o = (\ \beta_m\, z_{ref}\, g\ \theta_* \ / \ T\ )^{1/2} \tag{5.18}$$

and $\beta_m = 4.7$ is a dimensionless constant. An estimate for the temperature scale θ_* (in °K) is given by

$$\theta_* = 0.09(1 - 0.5 n^2) \tag{5.19}$$

where *n* is the fractional opaque cloud cover.

To obtain real-valued solutions for u_*, the following condition must be true:

$$4u_o^2 \ / \ (\ C_D^2 u^2\ ) \le 1 \tag{5.20}$$

Equality in the above condition corresponds to a minimum (critical) wind speed, u_{cr}. For wind speeds equal to or greater than u_{cr}, a real-valued solution to Eq. 5.16 is obtained. The critical wind speed is given by

$$u_{cr} = \left(4 \beta_m z_{ref}\, g\, \theta_* \;/\; (T C_D) \right)^{1/2} \tag{5.21}$$

For this value, there is a corresponding friction velocity, u_{*cr}, such that

$$u_{*cr} = C_D u_{cr} / 2 \tag{5.22}$$

For wind speeds less than this critical value, Eq. 5.16 no longer yields a real-valued solution. It is desirable to have $u_* \rightarrow 0$ as $u \rightarrow 0$. Therefore, for $u < u_{cr}$, u_{*cr} is scaled by the ratio u / u_{cr}, and u_* is calculated as

$$u_* = u_{*cr} \frac{u}{u_{cr}} \tag{5.23}$$

For $u < u_{cr}$, van Ulden and Holtslag (1985) showed that there is a near-linear variation of θ_* with u_*. Therefore, θ_* is scaled similarly as

$$\theta_* = \theta_{*cr} \frac{u_*}{u_{*cr}} \tag{5.24}$$

where $\theta_{*\mathrm{cr}}$ is given by 5.19.

With u_* from Eq. 5.16 or 5.23 and θ_* from Eq. 5.19 or 5.24, the heat flux for the stable atmosphere is computed from

$$H = -\rho c_p u_* \theta_* \quad . \tag{5.25}$$

Finally, using these estimates of u_* and H, L is computed from Eq. 5.9.

In the case of strong winds, H may become unrealistically large. Therefore, a limit of -64 W m^{-2} is placed on the heat flux, which forces a limit on the product $u_*\theta_*$. This yields a cubic equation in u_*, which is solved to obtain a new u_*. With this value for u_* and H = -64 W m^{-2}, L is recomputed from Eqs. 5.9 and 5.25.

The mechanically-generated (or mechanical) mixing height (z_{im}) is found from the diagnostic expression given by Venkatram (1980):

$$z_{im} = 2300 \; u_*^{3/2} \quad . \tag{5.26}$$

Since w_* is a scaling parameter for convective conditions, it is not computed for the stable atmosphere.

5.4.5 More on Mixing Heights

Mixing heights in AERMET are given special attention. During stable conditions, when L > 0, the mechanical mixing height is computed. During unstable conditions, defined when L < 0, both the convective and mechanical mixing heights are computed. As long as no data are missing to make the computations, this procedure yields a continuous record of mechanical mixing heights while the record for convective mixing heights is restricted to daytime hours of upward heat flux.

The mechanical mixing heights are smoothed so that the effect of any large hour-to-hour fluctuations of the surface friction velocity on z_{im} is reduced. The smoothing is performed for all hours - stable and unstable. The smoothed mechanical mixing height for the current hour ($t+\Delta t$) is given by:

$$\overline{z_{im}(t+\Delta t)} = \overline{z_{im}(t)}\, e^{-\Delta t/\tau} + z_{im}(t+\Delta t)\,[1 - e^{-\Delta t/\tau}] \tag{5.27}$$

where

$$\tau = \frac{\overline{z_{im}(t)}}{\beta_\tau \, u_*(t+\Delta t)}$$

and $\beta_\tau = 2.0$

The term with the overbar on the right hand side of Eq. 5.27 is the smoothed mechanical mixing height for the previous hour (t), $z_{im}(t+\Delta t)$ is the unsmoothed mechanical mixing height for the current hour ($t+\Delta t$) as determined from Eq. 5.26, and $u_*(t+\Delta t)$ is the surface friction velocity for the current hour. If $(t+\Delta t)$ is the first hour in the data base, then no smoothing is performed. Furthermore, if a missing mixing height occurs at time t, then the smoothing restarts at time $(t+\Delta t)$.

Both the smoothed mechanical and convective mixing heights are written to the output file for AERMOD.

The convective mixing height relies on the 1200 GMT (morning) sounding. AERMET retrieves data up to and including the first measurement level above 5000 meters. Occasionally, the sounding is lost at a low level (well below 5000 meters). When this situation happens, there may not be sufficient upper air data to allow AERMET to calculate the convective mixing height for all the daytime hours, particularly the late afternoon hours. To alleviate problems such as this, AERMET extends the sounding to 5000 meters by computing the potential temperature gradient in the upper 500 meters of the sounding and extends the sounding to 5000 meters as follows:

$$\theta(5000) = \theta(z_{top}) + \frac{d\theta}{dz}\bigg|_{500} (5000 - z_{top})$$

where z_{top} is the height of the original sounding and $d\theta/dz|_{500}$ is the potential temperature gradient in the upper 500 meters of the sounding. Messages are written to the message file at various stages: reports of soundings that do not extend to 5000 meters are reported in the Stage 1 QA; in Stage 3, the height of the original sounding and the potential temperature gradient that is used to extend the sounding is reported, as well as those periods when the sounding extension was required to compute a convective mixing height.

SECTION 6

REFERENCES

Auer, A.H. Jr. (1978): Correlation of land use and cover with meteorological anomalies. *J. Appl. Meteor*., **17**, 636-643.

Carson, D. J. (1973). The Development of a Dry Inversion-Capped Convectively Unstable Boundary Layer. *Quart. J. Royal Meteor. Soc.*, **99**:450-467.

Coulson, K. L., and D. W. Reynolds (1971). The Spectral Reflectance of Natural Surfaces. *J. Appl. Meteor.*, **18**:1495-1505.

Deardorf, J. W. (1980). Progress in Understanding Entrainment at the Top of a Mixed layer. Workshop on the Planetary Boundary Layer, J. C. Wyngaard (ed.). American Meteorological Society, Boston, MA, pp. 36-66.

Environmental Protection Agency (1987). *On-Site Meteorological Program Guidance for Regulatory Modeling Applications*. EPA-450/4-87-013, U.S. Environmental Protection Agency, Research Triangle Park, NC.

Environmental Protection Agency (1989). *Quality Assurance Handbook for Air Pollution Measurement Systems, Volume IV - Meteorological Measurements*. U.S. Environmental Protection Agency, Research Triangle Park, NC.

Environmental Protection Agency (2000). Meteorological Monitoring Guidance for Regulatory Modeling Applications. Publication No. EPA-454/R-99-005. Office of Air Quality Planning & Standards, Research Triangle Park, NC. (PB 2001-103606) (Available @ www.epa.gov/scram001/)

Högström and Högström (1978). A Practical Method for Determining Wind Frequency Distributions for the Lowest 200 m from Routine Data. *J. Appl. Meteor.*, 17, 942-954.

Holtslag, A.A.M., H.A.R. de Bruin, and A.P. van Ulden (1980). *Estimation of the Sensible Heat Flux from Standard Meteorological Data for Stability Calculations During Daytime*. Proceedings of the 11th International Technical Meeting on Air Pollution Modeling and Its Applications. Plenum Press, Amsterdam, pp. 401-407.

Holtslag, A. A. M. and A. P. van Ulden (1983). A Simple Scheme for Daytime Estimates of the Surface Fluxes from Routine Weather Data. *J. Climate Appl. Meteor.*, **22**:517-529.

Iqbal, M. (1983). *An Introduction to Solar Radiation*, Academic Press, NY.

Irwin, J.S. (1978). Proposed Criteria for Selection of Urban Versus Rural Dispersion Coefficients. Staff Report. Meteorology and Assessment Division, U.S. Environmental Protection Agency, Research Triangle Park, NC. (Air Docket Reference No. II-B-8 for the Fourth Conference on Air Quality Modeling).

Irwin, J.S. (1994). Personal Communication with Robert J. Paine, ENSR.

Kasten, F. and G. Czeplak (1980). Solar and Terrestrial Radiation Dependent on the Amount and Type of Cloud. *Solar Energy*, **24**:177-189.

NCDC (1989). NCDC Upper Air Digital Files, TD-6200 Series. National Climatic Data Center, Asheville, North Carolina.

Oke, T. R. (1978). *Boundary Layer Climates*, John Wiley and Sons, New York.

Oke, T.R. (1982): The energetic basis of the urban heat island. *Quart. J.Royal Meteor. Soc.*, **108**, 1-24.

Paine, R. J. (1987). *User's Guide to the CTDM Meteorological Preprocessor (METPRO) Program*. EPA-600/8-88-004, U.S. Environmental Protection Agency, Research Triangle Park, NC. (NTIS No. BP 88-162102).

Priestly, C.H.B. and R.J. Taylor (1972). On the Assessment of Surface Heat Flux and Evaporation Using Large Scale Parameters. *Mon. Wea. Rev.*, **100**: 81-92.

Stull, R. B. (1988). An Introduction to Boundary Layer Meteorology, Kluwer Academic Publishers, Dordrecht, The Netherlands, 666 pages.

Summers, P. W. (1965). An Urban Heat Island - Its Role in Air Pollution Problems, with Application to Montreal. First Canadian Conference on Micrometeorology. 12-14 April 1965, Toronto, Canada. 29 pp.

van Ulden, A. P., and A. A. M. Holtslag (1985). Estimation of Atmospheric Boundary Layer Parameters for Diffusion Applications. *J. Climate Appl. Meteor.*, **24**:1196-1207.

Venkatram, A. (1980). Estimating the Monin-Obukhov Length in the Stable Boundary Layer for Dispersion Calculations. *Bound.-Layer Meteor.*, **19**:481-485.

Weil, J. C., and R. P. Brower (1983). *Estimating Convective Boundary Layer Parameters for Diffusion Applications*, Draft Report, prepared by the Environmental Center, Martin Marietta Corp, for the state of Maryland.

APPENDIX A

FUNCTIONAL KEYWORD/PARAMETER REFERENCE

This appendix provides a functional reference for the keywords and parameters used by the input runstream files for AERMET. The keywords are organized by functional pathway and within each pathway the order of the keywords is alphabetical, excluding the keyword that identifies the start of a block. The pathways used by AERMET are as follows, in the order in which they appear in the tables that follow:

JOB -	for specifying overall **JOB** control options;
UPPERAIR -	for processing NWS **UPPER AIR** data;
SURFACE -	for processing NWS hourly **SURFACE** data;
ONSITE -	for processing **ONSITE** meteorological data;
MERGE -	to **MERGE** the three data types into one file;
METPREP -	for **MET**eorological data **PREP**aration for use in a dispersion model.

Two types of tables are provided for each pathway. The first table lists all of the keywords for that pathway, identifies each keyword as to its type (either mandatory or optional, either repeatable or non-repeatable, and if it is reprocessed), and provides a brief description of the function of the keyword. The second type of table, which may take up more than one page, describes each parameter in detail.

The following conventions are used in these tables. The parameter names are intended to be descriptive of the input variable being represented. Square brackets around a parameter indicate that the parameter is optional for that keyword. The default that is used when an optional parameter is left blank is explained in the discussion for that parameter.

TABLE A-1

DESCRIPTION OF JOB PATHWAY KEYWORDS

Keyword	Type	Description
JOB	Optional, Nonrepeatable	Start of JOB block. This statement is optional if the statements associated with this block appear first in the input control file.
MESSAGES	Mandatory, Nonrepeatable	Identifies the warning/error messages file.
REPORT	Optional, Nonrepeatable	Identifies the general report file.
CHK_SYNTAX	Optional, Nonrepeatable	Flag indicating that only the syntax of the input statements should be checked for errors, i.e., no data are processed.

TABLE A-2

DESCRIPTION OF KEYWORD PARAMETERS FOR THE JOB PATHWAY

Keyword	Parameters	
MESSAGES	message_filename	
	where: message_filename	The name of the file where all source-code-generated messages are written
REPORT	summary_filename	
	where: summary_filename	The name of the file where AERMET writes a summary of all preprocessor activity for the current run
CHK_SYNTAX	<none>	

TABLE A-3

DESCRIPTION OF UPPERAIR KEYWORDS

Keyword	Type	Description
UPPERAIR	Mandatory, Nonrepeatable	Start of UPPERAIR block.
AUDIT	Optional, Repeatable	Identify variables to be audited. These are in addition to any automatically audited variables.
DATA	Mandatory, Nonrepeatable	File name of raw upper air data.
EXTRACT	Mandatory, Nonrepeatable	File name of extracted upper air data.
LOCATION	Mandatory, Nonrepeatable, Reprocessed	Site ID and location information. Required only for extraction processing.
NO_MISSING	Optional, Repeatable	Identifies those variables to QA and summarize the messages only; detailed message identifying the violation and date is suppressed
MODIFY	Optional, Nonrepeatable, Reprocessed	Flag indicating corrections should be made to the sounding data when extracted. See §5 for a discussion of these corrections
QAOUT	Mandatory, Nonrepeatable	File name of upper air data for quality assessed output/ merge input
RANGE	Optional, Repeatable, Reprocessed	Set new upper and lower bounds and missing values for QA of the variable listed.
XDATES	Mandatory, Nonrepeatable	Inclusive dates identifying the period of time to extract from the archive data file.

TABLE A-4

DESCRIPTION OF KEYWORD PARAMETERS FOR THE UPPERAIR PATHWAY

Keyword	Parameter(s)	
AUDIT	uaname1 ... uanameN	
where:	uaname1 ... uanameN	Name(s) of variables that are to be tracked and reported during quality assessment (as defined in Table B-1 of Appendix B
DATA	archive_filename file_format [blocking_factor] [type]	
where:	archive_filename	The name of the file (or tape) containing the archive of upper air data
	file_format	Archive file format; valid parameters are: **6201FB** (TD-6201 fixed-length blocks) or **6201VB** (TD-6201 variable-length blocks) or **FSL** for data retrieved from Radiosonde Data of North America CD-ROM
	[blocking_factor]	Number of logical records in one physical record; default value is 1
	[type]	Collating sequence; valid parameters are: **ASCII** (default) or **EBCDIC** This parameter is needed only if AERMET is running on a computer that utilizes the EBCDIC collating sequence, such as IBM mainframe computers
EXTRACT	extracted_data_filename	
where:	extracted_data_filename	Name of the output file for data extracted from an archive data file and the name of the input file for upper air data QA

TABLE A-4, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE UPPERAIR PATHWAY

Keyword	Parameter(s)	
LOCATION	site_id lat(long) long(lat) tadjust	
where:	site_id	Station identifier for which data are to be extracted; for data from NCDC, this identifier is a WBAN number.
	lat(long)	Station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator (or W for sites west of Greenwich, E for sites east of Greenwich)
	long(lat)	Station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich (or N for sites north of the equator, S for sites south of the equator)
	tadjust	Number of time zones west (a positive value) or east (a negative value) of Greenwich
NO_MISSING	uaname1 ... uanameN	
where:	uaname1 ... ... uanameN	Suppresses missing data messages for the upper air variables specified, as defined in Appendix B; the number of time the variable is missing is not tallied
MODIFY	<none>	
QAOUT	qa_output_filename	
where:	qa_output_ filename	Name of the output file from the QA/input to merge data

TABLE A-4 (CONT.)

DESCRIPTION OF KEYWORD PARAMETERS FOR THE UPPERAIR PATHWAY

Keyword	Parameter(s)	
RANGE	uaname lower_bound <[=] upper_bound missing_indicator	
where:	uaname	Variable name, as defined in Table B-1
	lower_bound	Minimum value of the valid range of values for uaname
	<[=]	Exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA
	upper_bound	Maximum value of the valid range of values for uaname
	missing_indicator	Value to indicate the value is missing
XDATES	YB/MB/DB [TO] YE/ME/DE	
	YB/MB/DB	Beginning year, month and day to extract; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make this record more readable
	YE/ME/DE	Ending year, month and day to extract; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

TABLE A-5

DESCRIPTION OF SURFACE PATHWAY KEYWORDS

Keyword	Type	Description
SURFACE	Mandatory, Nonrepeatable	Start of SURFACE block.
AUDIT	Optional, Repeatable	Identify variables to be audited. These are in addition to any automatically audited variable.
DATA	Mandatory, Nonrepeatable	Input file name of raw surface data.
EXTRACT	Mandatory, Nonrepeatable	File name of extracted surface data.
LOCATION	Mandatory, Nonrepeatable, Reprocessed	Site ID and location information. Required only for extraction processing.
NO_MISSING	Optional, Repeatable	Identifies those variables to QA and summarize the messages only; detailed message identifying the violation and date is suppressed.
QAOUT	Mandatory, Nonrepeatable	File name for hourly surface data for quality assessed output/merge input.
RANGE	Optional, Repeatable, Reprocessed	Set new upper and lower bounds and missing values for QA of the variable listed.
XDATES	Mandatory, Nonrepeatable	Inclusive dates identifying the period of time to extract from the archive data file.

TABLE A-6

DESCRIPTION OF KEYWORD PARAMETERS FOR THE SURFACE PATHWAY

Keyword	Parameter(s)	
AUDIT	sfname1 ... sfnameN	
where:	sfname1 ... ... sfnameN	Name(s) of variable(s) that are to be tracked and reported during the quality assessment (as defined in Table B-2 of Appendix B).
DATA	archive_filename file_format [blocking_factor] [type]	
where:	archive_filename	The name of the file (or tape) containing the archive of hourly surface observations
	file_format	Archive file format; valid parameters are: **CD144** or **SCRAM** or **SAMSON** (data retrieved from SAMSON CD-ROM) or **3280VB** and **3280FB** or **HUSWO** (data retrieved from HUSWO CD-ROM) or **ISHD**[_nn]* (data archived in TD-3505 format)
	[blocking_factor]	Number of logical records per physical record; default value is 1
	[type]	Collating sequence; valid parameters are: **ASCII** (default) or **EBCDIC;** This parameter is needed only if AERMET is running on a computer that utilizes the EBCDIC collating sequence, such as an IBM mainframe computer
EXTRACT	extracted_data_filename	
where:	extracted_data_ filename	Name of the output file for data extracted from an archive data file

* The suffix '_nn' is used to overide the default window for ISHD extraction and is optioal; nn is the half width of the extraction window in minutes.

TABLE A-6, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE SURFACE PATHWAY

Keyword	Parameter(s)	
LOCATION	site_id lat(long) long(lat) [tadjust]	
where:	site_id	Station identifier for which data are to be extracted; for data from NCDC, this identifier is a WBAN number
	lat(long)	Station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator (or W for sites west of Greenwich, E for sites east of Greenwich)
	long(lat)	Station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich (or N for sites north of the equator, S for sites south of the equator)
	[tadjust]	Number of time zones west (a positive value) or east (a negative value) of Greenwich; for hourly observations, this value is usually Ø
NO_MISSING	sfname1 ... sfnameN	
where:	sfname1 ... sfnameN	Suppresses missing data messages for the surface variables specified, as defined in Appendix B; the number of time the variable is missing is not tallied
QAOUT	qa_output_filename	
where:	qa_output_filename	Name of the output file from the QA/input to merge data

TABLE A-6, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE SURFACE PATHWAY

Keyword	Parameter(s)	
RANGE	sfname lower_bound <[=] upper_bound missing_indicator	
where:	sfname	Variable name, as defined in Table B-2
	lower_bound	Minimum value of the valid range of values for sfname
	<[=]	Exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA
	upper_bound	Maximum value of the valid range of values for sfname
	missing_indicator	Value to use to indicate the observed variable is missing
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB	Beginning year, month and day to extract; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make this record more readable
	YE/ME/DE	Ending year, month and day to extract; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

TABLE A-7

DESCRIPTION OF ONSITE PATHWAY KEYWORDS

Keyword	Type	Description
ONSITE	Mandatory, Nonrepeatable	Start of ONSITE block.
AUDIT	Optional, Repeatable	Identify variables to be audited. These variables are in addition to any automatically audited variables.
DATA	Mandatory, Nonrepeatable	Input file name of site-specific data.
DELTA_TEMP	Optional, Nonrepeatable, Reprocessed	Define heights (meters) for temperature differences.
FORMAT	Mandatory, Repeatable, Reprocessed	FORTRAN format for reading one site-specific data record.
LOCATION	Mandatory, Nonrepeatable, Reprocessed	Site ID and location information.
NO_MISSING	Optional, Nonrepeatable	Identifies those variables to QA and summarize the messages only; detailed message identifying the violation and date is suppressed.
OSHEIGHTS	Optional*, Nonrepeatable, Reprocessed	Define heights of the site-specific measurements. * Mandatory if the heights are not in the data file.
OBS/HOUR	Optional*, Nonrepeatable	Number of observations each hour. * Mandatory only if the observations are more frequent than once per hour.

Table A-7, continued

DESCRIPTION OF ONSITE PATHWAY KEYWORDS

Keyword	Type	Description
QAOUT	Mandatory, Repeatable	File name of site-specific data for quality assessment output/merge input
RANGE	Optional, Repeatable, Reprocessed	Set new upper and lower bounds and missing values for QA of the variable listed.
READ	Mandatory, Repeatable, Reprocessed	Defines the name and order of variables as they appear in the site-specific DATA file.
THRESHOLD	Mandatory, Nonrepeatable, Reprocessed	Sets the minimum wind speed (meters/second) below which the wind is treated as a calm.
XDATES	Optional, Nonrepeatable	Inclusive dates for data processing.

TABLE A-8

DESCRIPTION OF KEYWORD PARAMETERS FOR THE ONSITE PATHWAY

Keyword	Parameter(s)	
AUDIT	osname1 ... osnameN	
where: osname1 ... ... osnameN		Name(s) of variables, as defined in Table B-3 of Appendix B, that are to be tracked during the quality assessment
DATA	filename	
where: filename		The name of the file containing the site-specific data
DELTA_TEMP	index lower_height upper_height	
where: index		Index for the i^{th} temperature difference measurement
lower_height		Lower measurement height for the i^{th} temperature difference
upper_height		Upper measurement height for the i^{th} temperature difference
FORMAT	record_index Fortran_format	
where: record_index		Specifies the record in the data observation to which the Fortran format refers.
Fortran_format		The Fortran format used to read the site-specific data record
LOCATION	site_id lat(long) long(lat) [tadjust]	

where: site_id	Site identifier for which data are to be processed.
lat(long)	Station latitude (or longitude) in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator (or W for sites west of Greenwich, E for sites east of Greenwich).
long(lat)	Station longitude (or latitude) in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich (or N for sites north of the equator, S for sites south of the equator).
[tadjust]	Number of time zones west (a positive value) or east (a negative value) of Greenwich; default value is Ø - for hourly observations, this value is usually Ø.

TABLE A-8, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE ONSITE PATHWAY

Keyword	Parameter(s)
NO_MISSING	osname1 ... osnameN
where: osname1 ... osnameN	Suppresses missing data messages for the site-specific variables specified, as defined in Appendix B; the number of time the variable is missing is not tallied
OSHEIGHTS	height1 ... heightN
where: height1 ... heightN	Heights of the site-specific data measurements; useful if the heights are not in the data file
OBS/HOUR	n_obs
where: n_obs	Number of time periods per hour the site-specific data are reported; for example if the data are recorded every 15 minutes, then n_obs = 4.
QAOUT	qa_output_filename
where: qa_output_filename	File name of the quality assessment output/merge input.

RANGE	osname lower_bound <[=] upper_bound missing_indicator	
where:	osname	Variable name, as defined in Table B-3.
	lower_bound	Minimum value of the valid range of values for osname.
	<[=]	Exclude (<) or include (<=) the lower and upper bounds (the endpoints) in the QA.
	upper_bound	Maximum value of the valid range of values for osname.
	missing_indicator	Value to use to indicate the value is missing.

TABLE A-8, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE ONSITE PATHWAY

Keyword	Parameter(s)	
READ	record_index osname1 ... osnameN	
where:	record_index	Links the list of variables names on this keyword statement to a Fortran format statement defined on a FORMAT keyword statement.
	osname1 ... osnameN	Specifies the list and order of variables in the site-specific data file that are to be read.
THRESHOLD	threshold_wind_speed	
where:	threshold_wind_speed	Minimum valid wind speed for the site-specific measurements; cannot exceed 1.0 ms^{-1}
XDATES	YB/MB/DB [TO] YE/ME/DE	

where: YB/MB/DB [TO] YE/ME/DE	Beginning year, month and day to QA; the slash (/) between each part of the date field is required; there can be no blanks in this parameter. Optional; used to make this record more readable. Ending year, month and day to QA; the slash (/) between each part of the date field is required; there can be no blanks in this parameter.

TABLE A-9

DESCRIPTION OF MERGE PATHWAY KEYWORDS

Keyword	Type	Description and Usage
MERGE	Mandatory, Nonrepeatable	Start of MERGE block.
OUTPUT	Mandatory, Nonrepeatable	File identifier for merged data.
XDATES	Optional, Nonrepeatable	Inclusive dates for data processing. If omitted, the earliest date found in the data is used as the beginning date and the ending date is 367 days later.

TABLE A-10

DESCRIPTION OF KEYWORD PARAMETERS FOR THE MERGE PATHWAY

Keyword	Parameter(s)	
OUTPUT	merged_data_filename	
	where: merged_data_filename	Name of the output file from STAGE 2.
XDATES	YB/MB/DB [TO] YE/ME/DE	
	where: YB/MB/DB	Beginning year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter.
	[TO]	Optional; used to make this record more readable.
	YE/ME/DE	Ending year, month and day to merge; the slash (/) between each part of the date field is required; there can be no blanks in this parameter.

TABLE A-11

DESCRIPTION OF METPREP PATHWAY KEYWORDS

Keyword	Type	Description and Usage
METPREP	Mandatory, Nonrepeatable	Start of METPREP block.
DATA	Mandatory, Repeatable	Input file identifier of merged data.
FREQ_SECT	Mandatory, Repeatable, Reprocessed	Number of surface characteristics by wind direction sector and time period. Must precede SECTOR and SITE_CHAR statements.
LOCATION	Mandatory, Nonrepeatable	Source information. All METPREP processing is performed relative to this location.
METHOD	Process dependent*, Repeatable	Redefine processing methodology used in generating output file for a particular variable. * - whether or not this keyword is mandatory depends on the processing to be performed and the data in the merged data base
MODEL	Optional, Nonrepeatable	Name of dispersion model for data are processed. Default: AERMOD
NWS_HGT	Optional*, Repeatable	NWS instrument height, in meters, for the specified variable. Default for wind: 10 m * - mandatory keyword if METHOD REFLEVEL SUBNWS is specified
OUTPUT	Mandatory, Nonrepeatable	File identifier for surface output data that will be input to the dispersion model.
PROFILE	Mandatory, Nonrepeatable	File name for the output profile data that will also be input to dispersion model.
SECTOR	Mandatory, Repeatable, Reprocessed	Defines a wind direction sector in degrees. See also FREQ_SECT and SITE_CHAR.

TABLE A-11, continued

DESCRIPTION OF METPREP PATHWAY KEYWORDS

Keyword	Type	Description and Usage
SITE_CHAR	Mandatory, Repeatable, Reprocessed	Define the direction-dependent surface characteristics of albedo, Bowen ratio, and surface roughness length (meters). See also FREQ_SECT and SECTOR.
XDATES	Optional, Nonrepeatable	Inclusive dates for data processing.

TABLE A-12

DESCRIPTION OF KEYWORD PARAMETERS FOR THE METPREP PATHWAY

Keyword	Parameter(s)	
DATA	merged_data_filename	
where:	merged_data_ _filename	The name of the file containing the merged NWS and, if any, site-specific data
FREQ_SECT	frequency number_of_sectors	
where:	frequency	Specifies how often the surface characteristics change; valid parameters are: MONTHLY - every calendar month SEASONAL - where the seasons are defined as: Spring = March, April, May Summer = June, July, August Autumn = September, October, November Winter = December, January, February ANNUAL - constant for the entire year
	number_of_ sectors	Specifies the number of wind direction sectors by which the surface characteristics vary
LOCATION	site_id source_lat(long) source_long(lat) [tadjust]	
where:	site_id	Site identifier for which data are to be processed.
	source_lat(long)	Latitude (or longitude) of the source(s) being modeled; in decimal degrees with the suffix N for sites north of the equator, S for sites south of the equator (or W for sites west of Greenwich, E for sites east of Greenwich).
	source_long(lat)	Station longitude (or latitude) of the source(s) being modeled; in decimal degrees with the suffix W for sites west of Greenwich, E for sites east of Greenwich (or N for sites north of the equator, S for sites south of the equator).
	[tadjust]	Number of time zones west (a positive value) or east (a negative value) of Greenwich.

TABLE A-12, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE METPREP PATHWAY

Keyword	Parameter(s)	
METHOD	atmos_variable option	
	where: atmos_variable	Identifies the variable that will be processed **WIND_DIR** - process NWS wind directions. **REFLEVEL** - substitute NWS data **STABLEBL** - specify option for SBL processing
	option	Processing option: For WIND_DIR, valid parameters are: **NORAND** - leaves NWS wind directions to the nearest 10° (default) or **RANDOM** - randomize NWS wind directions. For REFLEVEL, valid parameters are: **SUBNWS** For STABLEBL, valid parameters are: **BULKRN** - Bulk Richardson Number - This option requires site-specific measurements of temperature difference.
MODEL	model_name	
	where: model_name	Name of dispersion model the AERMET output is for; allowable names are: AERMOD

TABLE A-12, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE METPREP PATHWAY

Keyword	Parameter(s)	
NWS_HGT	variable_name instrument_height	
where:	variable_name	Weather variable that requires an instrument height to be defined; valid names are: WIND (to specify anemometer height)
	instrument_height	Height of the instrument, in meters.
OUTPUT	parameter_filename	
where:	parameter_ filename	Name of the output file from STAGE 3, with one record per hour
PROFILE	profile_filename	
where:	profile_name	Name of the output file containing multi-level data
SECTOR	sector_index beginning_direction ending_direction	
where:	sector_index	Index that links a specific set of site characteristics to a specific wind sector.
	beginning_ direction	Specifies the beginning wind direction of the sector, and is considered a part of this sector.
	ending_direction	Specifies the ending wind direction of the sector, and is NOT considered a part of the sector NOTE: the end of one sector must be the same as the beginning of the next sector.

TABLE A-12, continued

DESCRIPTION OF KEYWORD PARAMETERS FOR THE METPREP PATHWAY

Keyword	Parameter(s)	
SITE_CHAR	frequency_index sector_index albedo Bowen roughness	
where:	frequency_index	Index of the time period for which the surface characteristics apply; for ANNUAL on FREQ_SECT keyword, valid values: 1 (for the entire year) for MONTHLY on FREQ_SECT keyword, valid values: 1 ... 12 (corresponding to each month of the year) for SEASONAL on FREQ_SECT keyword, valid values: 1 = Winter = December, January, February 2 = Spring = March, April, May 3 = Summer = June, July, August 4 = Autumn = September, October, November
	sector_index	Sector corresponding to the direction from which the wind is blowing.
	albedo	Albedo for the frequency index and sector index specified.
	Bowen	Bowen ratio for the frequency index and sector index specified.
	roughness	Surface roughness length for the frequency index and sector index specified.
XDATES	YB/MB/DB [TO] YE/ME/DE	
where:	YB/MB/DB	Beginning year, month and day to process; the slash (/) between each part of the date field is required; there can be no blanks in this parameter
	[TO]	Optional; used to make this record more readable
	YE/ME/DE	Ending year, month and day to process; the slash (/) between each part of the date field is required; there can be no blanks in this parameter

APPENDIX B

VARIABLE NAMES AND DEFAULT QA VALUES

This appendix lists the variable names for each type of data and provides a short description of and the units for each variable, and gives the default bounds and missing value codes. This information is presented in the tables (Tables B-1, B-2, B-3a, B-3b) that follow, with each table divided into the following fields:

Variable Name

This is the four-character name that can be used on RANGE, AUDIT, and READ statements. An asterisk (*) indicates that the variable is automatically included in the QA for the path and need not be specified on an AUDIT record in the control file.

Description and Units

A brief description of each variable and the units follow the name. For UPPERAIR and SURFACE, real variables are stored as integers, in which case the units include a multiplier, such as *10 or *100, in order to maintain additional significant digits. For example, if the units are °C*10, then 1.5 °C is stored and referenced as 15.

Type of Check

The type of check determines whether to include (<=) or exclude (<) the lower and upper bounds in the range of acceptable values, and can be changed on a RANGE statement.

Missing Value Code

The missing value code is the value that AERMET interprets to mean that a value is not present. It is also the value written/stored by AERMET when the variable is not present or cannot be calculated.

Bounds

The last two fields are the lower and upper bounds that determine the interval of acceptable values. The value of the variable is accepted if it lies within this interval, where the endpoints are either included or excluded according to the Type of Check. Note that the multiplier, if present, must also be applied to these values.

TABLE B-1

VARIABLE AND QA DEFAULTS FOR THE UPPERAIR VARIABLES

Variable Name	Description	Units	Type	Missing Indicator	Lower Bound	Upper Bound
UAPR	Atmospheric pressure	millibars *10	<	99999	5000	10999
UAHT	Height above ground	meters	<=	-99999	0	5000
UATT	Dry bulb temperature	°C *10	<	-9990	-350	+350
UATD	Dew-point temperature	°C *10	<	-9990	-350	+350
UAWD	Wind direction	degrees from north	<=	999	0	360
UAWS	Wind speed	meters/second *10	<	9990	0	500
UASS	Wind speed shear	(m/s)/(100 meters)	<=	-9999	0	5
UADS	Wind direction shear	degrees/(100 meters)	<=	-9999	0	90
UALR	Temperature lapse rate	°C/(100 meters)	<=	-9999	-2	5
UADD	Dew point deviation	°C/(100 meters)	<=	-9999	0	2

TABLE B-2

VARIABLE AND QA DEFAULTS FOR THE SURFACE VARIABLES

Variable Name	Description	Units	Type	Missing Indicator	Lower Bound	Upper Bound
PRCP	Precipitation amount	millimeters * 1000	<=	-9	0	25400
SLVP[†]	Sea level pressure	millibars *10	<	99999	9000	10999
PRES	Station pressure	millibars *10	<	99999	9000	10999
CLHT	Ceiling height	kilometers *10	<=	999	0	300
TSKC	Total//opaque sky cover	tenths//tenths	<=	9999	0	1010
ALC1[a]	Sky cond//height, level 1	code//hundredths ft	<=	09999	0	300
ALC2[a]	Sky cond//height, level 2	code//hundredths ft	<=	09999	0	300
ALC3[a]	Sky cond//height, level 3	code//hundredths ft	<=	09999	0	300
ALC4[b]	Sky cond//height, level 4	code//hundredths ft	<=	09999	0	850
ALC5[b]	Sky cond//height, level 5	code//hundredths ft	<=	09999	0	850
ALC6[b]	Sky cond//height, level 6	code//hundredths ft	<=	09999	0	850
PWVC	Present weather (vicinity)		<=	9999	9292	98300
PWTH	Present weather		<=	9999	9292	98300
ASKY[c]	ASOS Sky condition	tenths	<=	99	0	10
ACHT[d]	ASOS Ceiling	kilometers * 10	<=	999	0	888
HZVS	Horizontal visibility	kilometers * 10	<=	99999	0	1640
TMPD[*]	Dry bulb temperature	°C *10	<	999	-300	350
TMPW	Wet bulb temperature	°C *10	<	999	-650	350
DPTP	Dew-point temperature	°C *10	<	999	-650	350
RHUM	Relative humidity	whole percent	<=	999	0	100
WDIR[*]	Wind direction	tens of degrees	<=	99	0	36
WSPD[*]	Wind speed	meters/second *10	<=	-9999	0	500

[*] Automatically included in audit report.
[†] A value < 800 in CD144 files is converted to SLVP/10.0 + 1000.0
// The two variables have been combined to form one variable; the missing value flags, as well as the upper and lower bounds have also been concatenated.

[a] ASOS sky condition (code table) and height (hundredths of feet) for levels 1-3
[b] ASOS sky condition (code table) and height (hundredths of feet) for levels 4-6 (augmented sites)
[c] ASOS sky condition (tenths), derived from layer data.
[d] ASOS ceiling (kilometers *10), derived from layer data.

ASOS Sky condition codes:
00 clear (less than 0.1)
02 scattered (0.1 to 0.5)
04 broken (0.6 to 0.9)
06 overcast (1.0)
07 obstruction (1.0)
09 unknown

TABLE B-3a

VARIABLE AND QA DEFAULTS FOR THE Site-specific SINGLE-VALUE AND DATE/TIME VARIABLES

Variable name	Description	Units	Type	Missing Indicator	Lower Bound	Upper Bound
HFLX	Surface heat flux	watts/square meter	<	999	-100	800
USTR	Surface friction velocity	meters/second	<	999	0	2
MHGT	Mixing height	meters	<	9999	0	4000
ZOHT	Surface roughness length	meters	<	999	0	2
SAMT	Snow amount	centimeters	<=	999	0	250
PAMT	Precipitation amount	centimeters	<=	999	0	100
INSO	Insolation	watts/square meter	<	9999	0	1250
NRAD	Net radiation	watts/square meter	<	999	-100	800
DT01	Temperature diff.(U - L)[1]	°C	<	9	-2	5
DT02	Temperature diff.(U - L)[1]	°C	<	9	-2	5
DT03	Temperature diff.(U - L)[1]	°C	<	9	-2	5
US01	User's scalar #1	user's units	<	999	0	100
US02	User's scalar #2	user's units	<	999	0	100
US03	User's scalar #3	user's units	<	999	0	100
ALTP	Altimeter pressure	inches mercury*100	<=	-9999	2700	3200
SLVP*	Sea level pressure	millibars *10	<	-9999	9000	10999
PRES*	Station pressure	millibars *10	<	-9999	9000	10999
CLHT*	Ceiling height	kilometers *10	<=	-9999	0	300
TSKC*	Sky cover (total/opaque)	tenths	<=	99	0	10
OSDY	Day		<=	-9	1	31
OSMO	Month		<=	-9	1	12
OSYR	Year		<=	-9	0	99
OSHR	Hour		<=	-9	0	24
OSMN	Minutes		<=	-9	0	60

[1](U - L) indicates (upper level) - (lower level).

TABLE B-3b

VARIABLE AND QA DEFAULTS FOR THE Site-specific MULTI-LEVEL VARIABLES

Variable name	Description	Units	Type	Missing Indicator	Lower Bound	Upper Bound
HT*nn*	Height	meters	<	9999	0	4000
SA*nn*	Std. dev. horizontal wind	degrees	<	99	0	35
SE*nn*	Std. dev. vertical wind	degrees	<	99	0	25
SV*nn*	Std. dev. v-comp. of wind	meters/second	<	99	0	3
SW*nn*	Std. dev. w-comp. of wind	meters/second	<	99	0	3
SU*nn*	Std. dev. u-comp. of wind	meters/second	<	99	0	3
TT*nn**	Temperature	°C	<	99	-30	35
WD*nn**	Wind direction	degrees from north	<=	999	0	360
WS*nn**	Wind speed	meters/second	<	999	0	50
VV*nn*	Vertical wind component	meters/second	<	999	0	5
DP*nn*	Dew-point temperature	°C	<	99	-65	35
RH*nn*	Relative humidity	whole percent	<=	999	0	100
V1*nn*	User's vector #1	user's units	<	999	0	100
V2*nn*	User's vector #2	user's units	<	999	0	100
V3*nn*	User's vector #3	user's units	<	999	0	100

nn in variables HT to V3 refers to the level at which the observation was taken; e.g., TT01 is the temperature at the first level and WS02 is wind speed at the second level.

*Automatically included in audit report.

APPENDIX C

DATA FILE FORMATS

This appendix describes the format of the data files created by AERMET. This includes the EXTRACT and QA files of NWS upper air and surface data, the merged file, and the OUTPUT and PROFILE files that will be input to AERMOD. It does not describe the QA file for site-specific data since this file is written with the same user-specified format used to read the original site-specific file.

The format of the files is given in terms of the FORTRAN READ statements that must be used to input the data for each observation. Variable names shown in capital letters correspond to those given in Appendix B. Variable names shown in lower case italics are "local" variables that do not correspond to any in Appendix B.

C.1 UPPER AIR SOUNDINGS

Each upper air sounding in both the EXTRACT and QA files is composed of two parts: (1) an identifying header record consisting of the year, month, day, hour, and the number of sounding levels; and (2) a sounding record composed of pressure, height above ground level, temperature, dew-point temperature, wind speed, and wind direction, which is repeated for each level.

Upper air header record:

READ( ) *year*, *month*, *day*, *hour*, # *levels*
FORMAT (1X, 4I2, I5)

where *hour* is expressed in local standard time (LST) and # *levels* is the number of levels in this sounding. If no soundings were extracted or there are no levels to the data, then # *levels* is zero.

Upper air sounding level data (if *# levels* > 0), repeated # *levels* times.

READ( ) UAPR, UAHT, UATT, UATD, UAWD, UAWS
FORMAT (6(1X,I6))

where UAPR = atmospheric pressure (millibars), multiplied by 10
UAHT = height above ground level (meters)
UATT = dry bulb temperature (°C), multiplied by 10
UAWD = wind direction (degrees from north)
UAWS = wind speed (meters/second), multiplied by 10

All values on the upper air pathway are written as integers. Several of the values were multiplied by 10, as noted above, to retain one significant digit after the decimal point prior to rounding the result to the nearest whole number. The values are divided by 10 prior to any usage in Stage 3.

C.2 SURFACE OBSERVATIONS

Each hourly surface observation in both the EXTRACT and QA files is written as two records. As with the upper air data, all values are reported as integers with several variables multiplied by 10 or 100 to retain significant digits. Several of the variables are two variables combined and stored as one integer value. These are recognized by the // in the variable name and units below.

The first record of a surface observation is written as follows:

READ( ) *year*, *month*, *day*, *hour*, PRCP, SLVP, PRES, CLHT, TSKC, C2C3, CLC1, CLC2, CLC3, CLC4
FORMAT (1X, 4I2, 4(1X,I5), 6(1X,I5.5))

where *hour* = hour in LST
PRCP = precipitation amount (millimeters), multiplied by 1000
SLVP = sea level pressure (millibars), multiplied by 10
PRES = station pressure (millibars), multiplied by 10
CLHT = cloud ceiling height (kilometers), multiplied by 10

TSKC	=	sky cover, total//opaque (tenths//tenths)
C2C3	=	sky cover, 2//3 layers (tenths//tenths)
CLC*n*	=	sky condition//coverage, layer *n* = 1,2,3,4 (−−//tenths)

The second record of a surface observation is written as follows:

```
READ( )   CLT1, CLT2, CLT3, CLT4, PWTH, HZVS, TMPD, TMPW, DPTP, RHUM,
          WDIR, WSPD
FORMAT (8X, 5(1X,I5.5), 7(1X,I5))
```

where	CLT*n*	=	cloud type//height, *n*=1,2,3,4 (−−//kilometers), multiplied by 10
	PWTH	=	present weather, liquid//frozen (no units, see codes below)
	HZVS	=	horizontal visibility (kilometers), multiplied by 10
	TMPD	=	dry bulb temperature (°C), multiplied by 10
	TMPW	=	wet bulb temperature (°C), multiplied by 10
	DPTP	=	dew-point temperature (°C),, multiplied by 10
	RHUM	=	relative humidity (percent)
	WDIR	=	wind direction (tens of degrees from north)
	WSPD	=	wind speed (meters/second), multiplied by 10

All reports of sky conditions (CLC*n*), cloud types or obscuring phenomena (CLT*n*) and present weather (PWTH) are stored using the TD-3280 numeric codes. This requires converting the appropriate variables in the CD-144 formatted file as a part of the extraction process. Since SCRAM uses the same convention, this discussion applies to that format as well. The following tables relate the TD-3280 codes to the CD-144 codes. Overpunch characters in the tables below for the CD-144 formats are represented by an ASCII character, which also appears in the data file. An “n.e.” indicates that there is “no equivalent” in the CD-144 format. Only weather producing liquid and/or frozen precipitation are reported in the PWTH variable.

TABLE C-1

SKY CONDITIONS

TD-3280	CD-144	Description of Sky Conditions
00	0	clear or less than 0.1 coverage
01	1	thin scattered 0.1 to 0.5 coverage
02	2	scattered 0.1 to 0.5 coverage
03	4	thin broken 0.6 to 0.9 coverage
04	5	broken 0.6 to 0.9 coverage
05	7	thin overcast 1.0 coverage
06	8	overcast 1.0 coverage
07	X or –	obscuration 1.0 coverage
08	blank	partial obscuration <1.0 coverage
09		unknown

TABLE C-2

CLOUD TYPES

TD-3280	CD-144	Description of Cloud Types
00	0	none
11	4	cumulus
12	n.e.	towering cumulus
13	K	stratus fractus
14	n.e.	stratus cumulus lenticular
15	3	stratus cumulus
16	2	stratus
17	M	cumulus fractus
18	5	cumulonimbus
19	N	cumulonimbus mammatus
21	6	altostratus
22	O	nimbostratus
23	7	altocumulus
24	n.e.	altocumulus lenticular
28	P	altocumulus castellanus
29	n.e	altocumulus mammatus
32	8	cirrus
35	n.e.	cirrocumulus lenticular
37	9	cirrostratus
39	R	cirrocumulus

TABLE C-3

OBSCURING PHENOMENA

TD-3280	CD-144 (cols. 30, 31)	Description of Obscuring Phenomena
01	6	blowing spray
03	3	smoke and haze
04	1	smoke
05	2	haze
06	4	dust
07	4	blowing dust
30	5	blowing sand
36	5	blowing snow
44	3	ground fog
45	1	fog
48	2	ice fog
50	n.e.	drizzle
60	n.e.	rain
70	n.e.	snow
76	n.e.	ice crystals
98	X or -	obscuring phenomena other than fog (prior to 1984)

The code definitions for present weather conditions (PWTH) are presented below. They are divided into nine general categories that are subdivided into specific weather conditions. Dashes in a field indicate that there is no definition for that code. The 8-digit CD-144 format for weather conditions is converted to the 2-digit TD-3280 categories. Up to two different types of weather may be stored in the PWTH variable in AERMET; however, only weather producing liquid (codes 20-39) and/or frozen (codes 40-69) precipitation are retained in the PWTH variable as liquid//frozen precipitation. The SAMSON codes for present weather are identical to the TD-3280 codes.

TABLE C-4

PRESENT WEATHER

TD-3280	CD-144 (col. 24)	Thunderstorm, Tornado, Squall
10	1	thunderstorm - lightning and thunder
11	2	severe thunderstorm - frequent intense lightning and thunder
12	3	report of tornado or water spout
13	5	light squall
14	n.e.	moderate squall
15	n.e.	heavy squall
16	n.e.	water spout
17	n.e.	funnel cloud
18	n.e.	tornado
19	n.e.	unknown
TD-3280	**CD-144 (col. 25)**	**Rain, Rain Shower, Freezing Rain**
20	1	light rain
21	2	moderate rain
22	3	heavy rain
23	4	light rain showers
24	5	moderate rain showers
25	6	heavy rain showers
26	7	light freezing rain
27	8	moderate freezing rain
28	9	heavy freezing rain
29	n.e.	unknown
TD-3280	**CD-144 (col. 26)**	**Rain Squall, Drizzle, Freezing Drizzle**
30	n.e.	light rain squalls
31	n.e.	moderate rain squalls
32	n.e	heavy rain squalls
33	4	light drizzle
34	5	moderate drizzle
35	6	heavy drizzle
36	7	light freezing drizzle
37	8	moderate freezing drizzle
38	9	heavy freezing drizzle
39	n.e.	unknown

TABLE C-4, continued

PRESENT WEATHER

TD-3280	CD-144 (col. 27)	Snow, Snow Pellets, Ice Crystals
40	1	light snow
41	2	moderate snow
42	3	heavy snow
43	4	light snow pellets
44	5	moderate snow pellets
45	6	heavy snow pellets
46	n.e.	light snow crystals
47	8	moderate snow crystals
48	n.e.	heavy snow crystals
49	n.e.	unknown
TD-3280	CD-144 (col 28)	Snow Shower, Snow Squalls, Snow Grains
50	1	light snow showers
51	2	moderate snow showers
52	3	heavy snow showers
53	n.e.	light snow squalls
54	n.e.	moderate snow squalls
55	n.e.	heavy snow squalls
56	7	light snow grains
57	8	moderate snow grains
58	9	heavy snow grains
59	n.e.	unknown
TD-3280	CD-144 (col. 29)	Sleet, Sleet Shower, Hail
60	n.e.	light ice pellet showers
61	n.e.	moderate ice pellet showers
62	n.e.	heavy ice pellet showers
63	n.e.	light hail
64	5	moderate hail
65	n.e.	heavy hail
66	8	light small hail
67	n.e.	moderate small hail
68	n.e.	heavy small hail
69	n.e.	unknown

TABLE C-4, continued

PRESENT WEATHER

TD-3280	CD-144 (col. 30)	Fog, Blowing Dust, Blowing Sand
70	1	fog
71	2	ice fog
72	3	ground fog
73	4	blowing dust
74	5	blowing sand
75	n.e.	heavy fog
76	n.e.	glaze
77	n.e.	heavy ice fog
78	n.e.	heavy ground fog
79	n.e.	unknown
TD-3280	CD-144 (col. 31)	Smoke, Haze, Blowing Snow, Blowing Spray, Dust
80	1	smoke
81	2	haze
82	3	smoke and haze
83	4	dust
84	5	blowing snow
85	6	blowing spray
86	n.e.	dust storm
87		– –
88		– –
89	n.e.	unknown
TD-3280	CD-144 (col. 29)	
90	1	light ice pellets
91	2	moderate ice pellets
92	3	heavy ice pellets
93		– –
94		– –
95		– –
96		– –
97		– –
98		– –
99	n.e.	unknown

C.3 MERGE OUTPUT

The merged data file contains a block of records that are the cumulative header records of all input files to Stage 2. These records are followed by blocks of records for each day of observations. Each block of records contains a header record identifying how many records there are in the block for each of the three types of data present. Each block is subdivided into three blocks of records, where each sub-block contains all of the observations for that day for a particular type of data.

The records within a block are written with an 8(I8,1X) format, except for the multi-level site-specific records that are written with a 6(F14.6,1X) format. The 22 NWS surface variables, plus the date and time, for each hour are split across four records. Also, if there are more than eight single-level or six multi-level variables on a particular READ statement, then these records will also be divided across more than one record.

<u>Daily Master Header Record</u>

READ( ) *year*, *month*, *day*, *j_day*, *n_ua*, *n_sfc*, *n_os*
FORMAT (7(I8,1X))

where	*j_day*	=	the Julian date for *year/month/day*.
	n_ua	=	number of NWS upper air observations.
	n_sfc	=	number of NWS surface observations.
	n_os	=	number of site-specific observations.

<u>Upper Air Records</u>

Upper air data are stored in the same order as in upper air extract/QA files (see D.1).

Surface Records

For each hour, there is a header record with the year, month, day and hour followed by three data records. The 22 variables are written in the same order as shown in D.2, with a maximum of 8 variables per record.

Site-specific Records

Single-level Variables

These are written in the same order and on multiple records just as they were given on the READ statements, but using an 8(I8,1x) format instead of that given on the corresponding FORMAT statements.

Multi-level Variables

Like the single-level variables, these are also written in the same order and on multiple records just as they were given on the READ statements, but using a 6(F14.6,1x) format.

C.4 AERMOD FILES

Two files are produced for input to the AERMOD dispersion model. The surface OUTPUT contains observed and calculated surface variable, one record per hour. The PROFILE file contains the observations made at each level of an site-specific tower, or the one level observations taken from NWS data, one record per level per hour. The contents of these files can also be written to the general report by including a LIST statement in the METPREP block.

SURFACE OUTPUT

Header record:

READ( ) *latitude, longitude, UA identifier, SF identifier, OS identifier, Version date*

FORMAT (2(2X,A8), 8X,' UA_ID: ',A8, ' SF_ID: ',A8, ' OS_ID: ',A8, T85, 'VERSION:', A6)

where *latitude* = latitude specified in Stage 3
longitude = longitude specified in Stage 3
UA identifier = station identifier for upper air data; usually the WBAN number used to extract the data from an archive data set
SF identifier = station identifier for hourly surface observations; usually the WBAN number used in extracting the data
OS identifier = site-specific identifier
Version date = AERMET version date; this date appears in the banner on each page of the summary reports

Data records:

READ( ) *year, month, day, j_day, hour,* H, u_* , w_* , *VPTG, PBL, SBL,* L, z_o , B_o , r, W_s , W_d , z_{ref} , *temp*, z_{temp}

FORMAT (3(I2,1X), I3,1X, I2,1X, F6.1,1X, 3(F6.3,1X), 2(F5.0,1X), F8.1,1X, F6.3,1X, 2(F6.2,1X), F7.2,1X, F5.0, 3(1X,F6.1))

where *j_day* = Julian date
H = sensible heat flux (W/m^2)
u_* = surface friction velocity (m/s)
w_* = convective velocity scale (m/s)
VPTG = vertical potential temperature gradient above PBL
PBL = height of convectively-generated boundary layer (m)
SBL = height of mechanically-generated boundary layer (m)
L = Monin-Obukhov length (m)
z_o = surface roughness length (m)
B_o = Bowen ratio
r = Albedo
W_s = wind speed (m/s)
W_d = wind direction (degrees)
z_{ref} = reference height for W_s and W_d (m)
temp = temperature (K)
z_{temp} = reference height for *temp* (m)

When site-specific data are included in the data base, the definition of the reference height wind speed and direction are subject to the following restrictions:

- the wind speed, W_s, must be greater than or equal to the site-specific data threshold wind speed;

- the measurement height must be above 7*z_0, where z_0 is the surface roughness length;

- the height must be less than 100 meters;

If AERMET is run only with NWS data, i.e. no site-specific data are in the data base, then the restrictions above do not apply and the reference winds are taken to be the NWS winds independent of the height at which the winds were measured.

Ambient air temperature is subject to a similar, but less restrictive, selection process:

- the measurement height must be above z_0;

- the height must be less than 100 meters.

<u>PROFILE</u>

READ( ) *year, month, day , hour*, height, top, WD*nn*, WS*nn*, TT*nn*, SA*nn*, SW*nn*

FORMAT (4(I2,1X), F6.1,1X, I1,1X, F5.0,1X, F7.2,1X, F7.1, 1X,F6.1, 1X,F7.2)

where	height	=	measurement height (m)
	top	=	1, if this is the last (highest) level for this *hour*, or 0 otherwise
	WD*nn*	=	wind direction at the current level (degrees)
	WS*nn*	=	wind speed at the current level (m/s)
	TT*nn*	=	temperature at the current level (°C)
	SA*nn*	=	σ_θ (degrees)
	SW*nn*	=	σ_w (m/s)

APPENDIX D

SUMMARY OF MESSAGES

During the processing of the runstream input and data files, AERMET writes messages to the file defined through the MESSAGES keyword on the JOB pathway. Each message has the form:

$$n\ \ block\ \ a_1 n_1 n_2\ \ ssssss\text{:}\ \ message$$

where

n	= counter, date (in the form yymmdd), or blank
block	= program block name
$a_1n_1n_2$	= message code
ssssss:	= subroutine name in which the message was generated
message	= message (limited to 48 characters)

The counter *n* is either the sequence number of the keyword statement generating the message, zero when irrelevant, the Julian day plus the hour of an observation with a QA violation or the number of observations when processing is completed. If it is a sequence number, it may be relative to either the current runstream file or to the header statements of a file.

The message code is composed of a letter (a_1) and a 2-digit code (n_1n_2). The letter can be one of the following:

E Indicates a fatal error; if the error occurs during processing of keyword statements, the remaining statements are processed for syntax only. If the error occurs during the processing of data, processing ceases for the run.

W Indicates a potential problem that the user should check. Runstream and data processing continues.

I Provides information on the status of the processing; these messages report on the progress of an AERMET run.

Q Indicates a quality assessment violation; a value for a variable was either outside the interval defined by the upper and lower bounds or it was missing.

The 2-digit codes are grouped into general categories corresponding to the processing in Stages 1, 2, and 3. These categories are:

00 - 29 Input statement processing, file header and general processing that is applicable to all pathways;

30 - 39 Upper air sounding processing

40 - 49 Surface observation processing

50 - 59 On-site observation processing

60 - 69 Merge processing

70 - 89 Stage 3 processing

These codes only provide an indication of the processing (runstream or data) that was occurring. They cannot completely specify the reason for the message. Further explanation is left to the 48-character message.

D.1 INTERPRETING ERROR MESSAGES

AERMET can generate many messages in a single run. This section discusses the interpretation of a few of the error messages.

Anyone who has written software knows that a single syntax error in the source code can generate several error messages when the program is compiled. AERMET also may generate several error messages for an error in a runstream. The following is an example of such a situation that could occur in defining the surface characteristics in Stage 3.

Runstream fragment for the METPREP pathway:

```
FREQ_SECT  ANNUAL      1
SECTOR          1      0      360
CHARS           1      1      0.250 0.750 0.006
```

The message file would contain something like:

```
16  METPREP   E03   ST3SET:     KEYWORD UNKNOWN:  CHARS
   METPREP    I19   ST3SET:     "END OF FILE" ON UNIT 5 AFTER RECORD #  16
   METPREP    E29   MPTEST:     EXPECTED 1 SITE_CHAR KEYWORD; 0 PROCESSED
   METPREP    E29   MPTEST:     ERROR FOR PERIOD 1, SECTOR 1
```

The correct keyword was not used to define the surface characteristics: CHARS instead of SITE_CHAR. As each runstream record is processed, AERMET checks to make sure that it conforms to all the rules of syntax. The first message indicates that an unknown keyword was detected (by subroutine ST3SET) at record 16 in the runstream. Once the runstream is completely processed, as noted by the "END OF FILE" message, AERMET checks to be sure it has enough information to process the data. It is during this portion of the setup processing, in subroutine MPTEST, that AERMET detects additional problems. Based on the FREQ_SECT keyword, AERMET expected a single SITE_CHAR keyword (annual, one sector covering all wind directions) to define the surface characteristics, but it did not find any valid SITE_CHAR keywords (third message). The final message indicates that there was some kind of error with the first period for sector 1 and is tied to the third message.

One might argue that the number of error messages is excessive for such a minimal configuration for the surface characteristics. Remember that there can be up to 12 SECTOR keywords and 144 SITE_CHAR keywords, so AERMET provides the user with additional information to assist in identifying the exact location of the problem.

Another error that causes multiple error messages occurs when a pathway is misspelled. Depending on the location in the runstream, AERMET reports it as an unknown pathway/keyword (the syntax and structure of the runstream makes it impossible to determine which). Since the pathway is not correctly defined, the keywords that follow it would be reported as invalid for the previous pathway.

Another error that a user could introduce is a misspelling of an input data file name. AERMET opens and processes file headers, if any, before processing any data. If a nonexistent file is opened, the file is created and is 0 bytes long. If there is critical information that is to be reprocessed from the header records of the correctly spelled file, then AERMET will not find that information in the incorrectly spelled file and report an error. Unfortunately, the message resulting from such an error is misleading. There is no way to recognize a 'zero-length' file using ANSI-standard Fortran at the point AERMET checks for sufficient information to process the data. For example, in merging data, if the input file name for the site-specific data (specified on the keyword QAOUT) is misspelled, then AERMET creates the (misspelled) file, reads from the file (and immediately encounters an end of file), and reports that there are no READ/FORMAT keywords to define the data structure.

Most error messages are reasonably straightforward to interpret. However, from these few examples, one can see that is may take a little more than a casual glance at the message file if AERMET detects any errors during setup.

In the discussion of the error messages, the term ‘decode’ (or a variant) is used. In Fortran, this term means that the program is translating data and transferring data between variables in internal storage rather than transferring data from an external file to variables. The term ‘internal read’ may also be seen in this context.

D.2 RUNSTREAM AND FILE HEADER PROCESSING, 00 – 29

Any messages that pertain to the setup of a run are included in this category.

<u>ERRORS</u>

E00 Reserved - this code is used to report internal programming errors.

E01 AERMET was not able to read a record in the runstream.

E02 Error defining the pathway - the conditions that may result in this error are:
1) Subr.FDPATH, in a call to subr.GETWRD, was not able to determine the pathway for the runstream record number indicated;
2) Invalid pathway for the stage of processing;
3) Duplicate pathway specified.
The message identifies which condition was encountered.

E03 Error defining a keyword - the conditions that may result in this error are:
1) The keyword did not match any of the 26 keywords recognized by AERMET. This error is independent of pathway;
2) The keyword is not valid for the pathway;
3) The keyword was duplicated for the pathway; only selected keywords are repeatable.
The message identifies which condition was encountered. See the tables in Appendix A for the list of keywords by pathway.

E04 Incomplete or superfluous information for a keyword. See the tables in Appendix A for the syntax of the keyword.

E05 <not used>

E06 The parameter associated with a keyword is in error. This error can be generated for multiple reasons. For example, if AERMET could not match a variable name on a keyword with the list of valid variable names, then this error code is used. Also, if AERMET has a ‘decoding’ error, then this code is used. A parameter on a keyword statement is not within bounds, is not known, or does not match any of the valid secondary keywords or parameters for this keyword.

E07 An error occurred in subroutine GETWRD or an error condition was returned to the calling routine. This subroutine retrieves the value of a field, whether it be a pathway, keyword, or parameter field, for additional processing.

E08 Error opening a file or the file name was previously specified for another file that is already open.

E12 Processing cannot be completed because a required keyword statement for the specified block is either missing or in error.

E15 A problem was encountered with the site-specific surface characteristics defined in Stage 3. A possible error is that the keywords were not specified in the correct order. While most keywords can appear in any order for a pathway, the surface characteristics must appear in a particular order. See Section 4.7.7 for a discussion of the keywords.

E19 The chronological day was not computed correctly from the year, month and day (in SUBR.CHROND); or the year, month and day was not computed correctly from the chronological day (in SUBR.ICHRND).

E20 Error reading a header record from a file (including temporary files). This error could occur while reading through the header records of a file in an attempt to locate the first data record.

E21 Error writing a header record to a file.

E22 End of file encountered reading and existing file’s header records. This condition indicates that there are no data to process.

E23 Error re-reading an existing file’s header records written that had been written to an output file.

E24 Error conditions were detected for the JOB pathway; this message is issued during the final check after the setup processing.

E25 Error conditions were detected for the UPPERAIR pathway; this message is issued during the final check after the setup processing.

E26 Error conditions were detected for the SURFACE pathway; this message is issued during the final check after the setup processing.

E27 Error conditions were detected for the ONSITE pathway; this message is issued during the final check after the setup processing.

E28 Error conditions were detected for the MERGE pathway; this message is issued during the final check after the setup processing.

E29 Error conditions were detected for the METPREP pathway; this message is issued during the final check after the setup processing.

WARNINGS

W06 Value on an input statement may be unreasonable, but processing continues with this value.

W10 A non-fatal error while attempting to write to a temporary file.

W12 An input statement for the block may be missing or in error; this message depends on the processing requested.

W15 Auditing a variable for QA is disabled for the on-site variable specified. The variable appeared on an AUDIT keyword statement but did not appear with any READ keywords.

W22 An end-of-file was encountered while reading the headers on an input file – data will not be processed for this block. This is likely a fatal error but is treated as a nonfatal error so the remainder of the data can be processed.

INFORMATIONAL

I25 No data are to be extracted, QA'd, or merged for UPPERAIR pathway.

I26 No data are to be extracted, QA'd, or merged for SURFACE pathway.

I27 No data are to be QA'd or merged for ONSITE pathway.

I19 End-of-file encountered on the input runstream file.

D.3 UPPER AIR PROCESSING, 30 – 39

Any messages that pertain to the UPPERAIR pathway and issued after the input statements are processed are in this category. A word of caution: if a problem requires examining the unprocessed TD-6201 (archive) data, be very careful if you edit the file with a text editor. Some editors could potentially modify the structure, rendering the file unreadable by AERMET. A better option would be to use a file viewer that cannot alter a file.

ERRORS

E31 No soundings were extracted and there were no errors that did not allow AERMET to extract any of the soundings specified in the runstream. Compare the station ID and the dates in the runstream to the station and dates in the input data file.

E32 An error occurred reading a block of data. A block of data contains all or part of a single sounding. Depending on the data structure of the archive data (fixed- or variable-length block), there can be up to 2876 characters in one block of data. An error reading a block is considered severe enough to stop processing the upper air data since the nature of the error cannot be ascertained very easily. The user will have to carefully examine the data to determine the cause of the error.

E33 An error was encountered decoding the portion of the block that contains the station identifier and date group, or an error occurred decoding a level of data in the sounding. In the former case, AERMET will stop processing the upper air data. In the latter case, AERMET will allow up to five such errors decoding sounding levels before processing of upper air data ceases. If AERMET cannot decode a sounding level, then it continues to the next level.

E34 The first character of the station ID is blank in the archive data file, indicating that the entire field likely is blank in the file. In the archive file, the station ID is supposed to fill the entire 8-character field, with leading 0's to fill out the field if the ID is shorter than eight characters. Either the process of reading the data is no longer synchronized with the data, or the station ID field is not what AERMET expects.

E35 At least one sounding was extracted, but error(s) occurred that did not allow AERMET to finish extracting all the soundings specified in the runstream.

E36 No soundings were extracted and error(s) occurred that did not allow AERMET to extract any of the soundings specified in the runstream.

E38 An error occurred while reading a sounding during the QA process. The data in the input file for QA should already be in a standard AERMET format (see Appendix C.1), but AERMET was unable to read the data from the file. Since AERMET reads and writes one sounding at a time, check the output file to see where the error occurred (the sounding after the last one in the file being written by the QA process).

E39 AERMET was not able to compute the range of heights required for the QA. Since the heights reported vary from sounding to sounding based on the structure of the atmosphere, AERMET constructs height intervals into which the QA results are categorized. This error should never occur since the height intervals are computed internally based on a layer thickness defined within the software and not the sounding data.

WARNINGS

W33 Error decoding a level of data, but the maximum number of errors allowed (five) has not been exceeded.

W33 Surface elevation (elevation of the first sounding level) is missing or less than zero. The sounding levels in the archive file are reported as height above mean sea level. AERMET adjusts all soundings to be referenced relative to the local elevation rather than sea level. If AERMET cannot determine the surface elevation because it is missing (or below mean sea level), then this message is issued. Once the surface elevation is determined, that elevation is used to adjust all subsequent soundings.

W35 The process of decoding the levels of data in a sounding failed at the first level. It is likely that only a header record is present in the output file from the extract process. The user will have to examine the input data more closely to determine the cause of the problem.

INFORMATIONAL AND QA

I30 Beginning UPPERAIR data processing.

I31 Data modifications for upper air soundings is enabled. See Section 5 for a discussion of these modifications.

I32 With the data modifications enabled, a level of data was deleted or modified from a sounding.

I39 End-of-file was encountered on the input file.

Q34 A vertical gradient cannot be computed at because at least one of the heights are missing.

Q35 The difference between the reported height and recomputed height exceeds 50 meters.

Q36 The heights have not been recomputed due to missing data.

Q37 A lower bound quality assessment violation for the variable indicated.

Q38 An upper bound quality assessment violation for the variable indicated.

Q39 The data value for this period and variable is missing.

D.4 SURFACE OBSERVATIONS PROCESSING, 40 – 49

Any messages that pertain to the SURFACE pathway and issued after the input statements are processed are in this category.

ERRORS

E41 An end of file was encountered in the input file and no hourly observations were extracted. Compare the station ID and dates in the runstream to the station and dates in the input file to determine if there is a mismatch.

E42 The maximum number of errors allowed reading a block of data from the archive data file has been exceeded. The limit is five errors.

E43 An internal read (decode) failed while trying to resolve the station ID or date group in the archive input data.

E44 The first character of the station ID is blank in the archive data file, indicating that the entire field likely is blank. Check the input file and make sure the file structure conforms to the format specified on the DATA card (e.g., if CD144 is specified on the DATA keyword, then the format of the file is the 80-character per observation format).

E45 No data fields useful to AERMET were defined when data were retrieved from the SAMSON CD. AERMET expects that the data the user retrieved from the SAMSON CD contains information that is required to calculate boundary layer parameters. This message is issued during the setup phase of the processing.

E46 An error occurred converting the variable ID number in a SAMSON input file from a string to an integer. The second record of the data retrieved from the SAMSON CD contains a list of integers that correspond to the weather variables that appear in the file. The integers range from 1 through 21. Without a correct interpretation of these integers, AERMET cannot process the data.

E47 The station ID in the SAMSON file does not match the station ID on the LOCATION keyword. See also E41; since the SAMSON data are processed slightly differently than the CD144 and SCRAM formats, a separate message is issued when no data are retrieved.

E48 An error was encountered while reading the hourly observation from the QA input file. Since AERMET reads and writes one observation at a time, check the output file to see where the error occurred (the observation after the last one in the file being written by the QA process).

<u>WARNINGS</u>

W42 Error reading/decoding the hourly observations, but the maximum number of errors allowed was not exceeded.

W43 An error occurred decoding an overpunch character – the missing value code for that variable will be substituted in the output file. See Section 4.3.1 for a discussion on overpunches. The number of the overpunch is reported (there are 35 overpunches possible, but AERMET does not examine all of them), and the table in Section 4.3.1.1 can be used to identify the position in the record that caused the error.

W44 The element name could not be located among the list of possible names (defined in the array VNAMES) for the TD-3280 data. The names of the variables in Table B-2 are the names used in the TD-3280 data format. A mismatch at this point likely indicates that either the names in the TD-3280 file have been changed, the names in AERMET have been changed, or the data file is corrupted. Processing continues, but the output might not be complete. Check the documentation for the TD-3280 format to see if the names were updated after AERMET was written. Recompiling and relinking STAGE1N2 could eliminate the error if the executable became corrupted.

W46 AERMET has encountered a second set of SAMSON header records (the records beginning with the tilde (~)). These header records are not processed and the extraction of hourly surface observations stops.

W47 An error occurred converting the station ID on the 'LOCATION' keyword from character to integer; processing will continue, blindly assuming that the data in the file are what the user wants. AERMET makes an integer to integer comparison of the station IDs when SAMSON data are processed, not a comparison of character variables as for the other formats supported by AERMET.

INFORMATIONAL AND QA

I40 Processing of the SURFACE data can begin.

I47 The SAMSON data identified with this message were modeled rather than observed when the data were imprinted on the CD.

I49 End-of-file was encountered on the input file.

Q47 A lower bound quality assessment violation for the variable indicated.

Q48 An upper bound quality assessment violation for the variable indicated.

Q49 The data value for this period and variable is missing.

D.5 ON-SITE DATA PROCESSING, 50 – 59

Any messages that pertain to the ONSITE pathway and issued after the input statements are processed are in this category.

ERRORS

E50 Error reading an input file header.

E51 Error reading input file header record. This message would occur only if a file is QA'd more than once since there isn't an extract process for site-specific data and there usually aren't any headers in the site-specific data file prior to the first time the data are QA'd.

E52 The maximum number of errors allowed reading/decoding the input data has been exceeded. The limit is five errors.

E53 Error writing data to the output file defined on the QAOUT keyword statement.

E54 The observations are not sequential in time.

E55 The number of observations exceeds the number expected for the hour (by default, 1 or the value specified on the OBS/HOUR keyword statement).

E56 End-of-file on the input data was encountered before a complete observation (block of records) was read.

WARNINGS

W52 Error reading/decoding the input data, but the maximum number of errors allowed was not exceeded.

INFORMATIONAL

I57 An intra-hour observation violated a quality assessment lower bound for the variable specified.

I58 An intra-hour observation violated a quality assessment upper bound for the variable specified.

I59 An end-of-file was encountered on the input file.

Q57 A lower bound quality assessment violation for the variable specified (for more than one observation per hour, this check is made after the subhourly values have been averaged).

Q58 An upper bound quality assessment violation for the variable specified (for more than one observation per hour, this check is made after the subhourly values have been averaged).

Q59 The data value for this variable and observation period is missing.

D.6 MERGE PROCESSING, 60 – 69

Any messages pertaining to merging the three data types and issued after the input statements are processed are in this category.

ERRORS

E60 Error computing the chronological day from Julian day and year.

E61 Error computing the Julian day and year from the chronological day.

E62 Error reading the UPPERAIR data.

E63 Error reading the SURFACE data.

E64 Error reading the ONSITE data.

E65 Error writing the ONSITE QA'd data to the OUTPUT file.

E66 Error processing an input file's headers.

E67 No data to merge - either the merge program or the setup have determined that there are no data to merge. AERMET will 'merge' data even if there is only one type of data (upper air, surface, or site-specific), but

INFORMATIONAL

I67 No XDATES statement – the beginning chronological day was computed as the earliest available date on the three pathways, and the ending chronological day was computed as the beginning day + 367. Without an XDATES keyword, AERMET has no knowledge of what data are in the input file(s), therefore, the zeroes are displayed in the report file for the dates to merge.

D.7 STAGE 3 PROCESSING, 70 – 89

Any messages that pertain to Stage 3 processing and issued after the input statements are processed are in this category.

ERRORS

E70 Error reading the master header from the merged data file for the Julian day shown. In the merged data file, there is a master header that precedes the data for each 24-hour block of data. AERMET was unable to read this record.

E71 There was an end-of file or error encountered reading the merged upper air data.

E72 There was an end-of file or error encountered reading the merged hourly surface observations.

E73 There was an end-of file or error encountered reading the merged site-specific data.

E74 The data are not on a 1-to-24 hour clock. This message can appear for surface or site-specific data. Although the program to merge the data should write the data on a 1-to-24 hour clock, there appears to be an hour outside this window, possibly an hour labeled 0.

E75 There was an error converting the latitude and longitude in the runstream file from character to numeric.

E76 The hour in the merged data is defined as missing. For an unknown reason, the value for the hour was set to -9 in the merged data file.

E77 Bad wind sector specified (this is a second check on the wind direction sector).

<u>WARNINGS</u>

W70 The LST to GMT conversion appears to be incorrect. Based on the longitude provided, the (elementary) computation of the time zone does not agree with the conversion parameter (tadjust) on the LOCATION keyword.

W71 Missing data. There are several possibilities for this warning code:
- no data for the day;
- the scheme to define the reference wind speed and temperature for the hour could not locate valid values because one of the criteria could not satisfied, including no NWS data substitution when the site-specific dat do not satisfy the criteria;
- calm winds.

W72 The upper air sounding cannot be extended because
- the maximum number of levels are in the sounding;
- the top of the sounding is too low (< 600 meters);
- could not identify two levels with which to calculate the potential temperature gradient required to extend the sounding.

W73 Convective boundary layer parameters not computed because
- no upper air data, especially the 12Z sounding, reported on this day
- other data required for the computation of the daytime planetary boundary layer height are missing.

W74 Cloud clover is missing for a nighttime hour or both cloud cover (NWS) and net radiation (site-specific) are missing for a daytime hour, prohibiting calculation of all boundary layer parameters in AERMET.

W75 The sounding was extended and the computed convective mixing height calculates the mixing height to be between the top of the original sounding and the top of the extended sounding.

W76 Calculated or site-specific value for incoming solar radiation, net radiation, surface friction velocity, or surface heat flux is out of range (relative to the QA lower and upper bounds).

W77 Net radiation is negative during a daytime hour or positive during the nighttime (relative to sunrise and sunset).

W78 Calculated value for density or surface albedo is out of range (relative to lower and upper bounds specified at the point this check is made).

W79 Site-specific mixing heights are in the data base, but are missing for the hour; AERMET will calculate the mixing height.

W80 The conditions that produce this message are:

1) The reference wind speed from the site-specific data are above the threshold wind speed but less than $2^{½} *\sigma_{v,min}$ (where $\sigma_{v,min} = 0.2$ m s^{-1}), or

2) The reference wind speed height is above $7z_0$ but below $20z_{0,}$ where z_0 is the surface roughness length. See the Site-specific Meteorological Program Guidance (EPA, 1987) for additional discussion on specifying the height to use in calculating boundary layer parameters.

W81 The reference wind speed from the NWS data are above the threshold wind speed but less than $2^{½} *\sigma_{v,min}$ (where $\sigma_{v,min} = 0.2$ m s^{-1}). This condition is not likely to occur since the minimum wind speed reported by NWS is 1 knot (about 0.5 m s^{-1}), excluding calm winds.

W82 The default pressure of 1013.25 mb is being used since there were no site-specific or NWS pressure reported.

INFORMATIONAL

I70 Hour 23 data was swapped in for hour 24 data for NWS surface data.

I71 NWS data were substituted in the profile. All site-specific data are missing for the hour; one-level profiles consisting of NWS winds and temperature are being substituted (but only if the user specified NWS substitution in the runstream with the METHOD SUBNWS keyword).

I79 The end of the processing window, defined by the XDATES statement for the METPREP block, was encountered or, if no window was specified, the end-of-file was encountered.

I81 In defining the reference wind speed, there were no site-specific winds that met the criteria and NWS winds were used for the reference wind speed.

I82 In defining the reference temperature, there was no site-specific temperature that met the criteria and NWS temperature was used for the reference wind speed.

I83 In defining the station pressure, there was no site-specific pressure and NWS winds were used for the reference wind speed. This message is seen only if the user indicates that there is pressure in the data base.

APPENDIX E

PROCESSING NWS DATA FROM MAGNETIC TAPE

Extracting data from magnetic tape as it pertains to the AERMET command language is discussed in this appendix. This discussion is primarily for users who run AERMET on computer platforms that can access magnetic tape drives, such as Digital Equipment Corporation's VAX computers. There is no attempt to describe the system control language required to mount tapes and assign file names. The user is directed to the appropriate system user's manuals for such information.

The only data that is considered here is the National Weather Service data; no attempt is made to read site-specific data directly from magnetic tape. When running AERMET on a computer that can access a magnetic tape drive, the user only needs to be aware of a few changes and additions to the AERMET command language. These modifications have to do with the DATA keyword for the SURFACE and UPPERAIR pathways.

E.1 SURFACE PATHWAY

Recall the syntax of the keyword statement:

Syntax:	DATA *archive_filename* *file_format* *factor* [*type*]
Type:	Mandatory (Stage 1), Nonrepeatable

where the *archive_filename* is the name of the file and must conform to the naming conventions appropriate to the computing platform. The maximum length of the *archive_filename* is 48 characters. For processing data from tape, the *archive_filename* is the "name" of the tape, however that name is specified or defined for the computing platform. For example, the name of the tape on a VAX is defined in the system control language that is used to mount the tape on the tape drive.

An additional data format is accessible when working with magnetic tapes. AERMET can process the TD-3280 format available from NCDC. This format is an element-based format in which the data for an entire day is reported one element (weather variable) at a time. To process NWS hourly surface observations in this format, the parameter 3280VB or 3280FB is specified for the *file_format*. The suffixes VB and FB refer to **v**ariable-length and **f**ixed-length **b**lock records, respectively. For variable-length data, each logical record contains one station's hourly data values for one meteorological element (weather variable) for as many hourly values as occur in the day. For fixed-length data, each logical record contains one station's hourly data values for on meteorological element for 24 hourly values representing one full day of observations. Specification of this suffix depends on how the data were ordered from NCDC. The data are archived at NCDC in the variable-length format and usually supplied to the user in that format, but the user can request NCDC to supply the data in the fixed-length format.

In addition to the TD-3280 format, AERMET can process the CD-144 data discussed in Sections 2 and 3 if it is received on magnetic tape. The *file_format* for this data format is CD144FB, just as if the data are on disk, where the FB indicates that there is a fixed number of characters per logical record. There is no variable-length block option for the CD-144 data format.

The parameter *factor* defines the number of logical records per physical record (or blocking factor), i.e., the number of logical records to process before reading from the tape again. The specification of this factor depends, in part, on the data request submitted to the NCDC. For the TD-3280 format, this factor is 1. For the CD-144 data format, this factor is usually 10. One logical record contains one hour of surface meteorological observations; therefore, a *factor* of 10 indicates that there are 10 logical records, or 10 hours of data, per physical record. If data on tape from NCDC are used, the blocking factor for the particular data format must be specified correctly for AERMET to properly extract the data from magnetic tape. Otherwise, an error reading the physical record may occur (for a factor that is too large) or there will be skips in the data record (for a factor that is too small).

The *type* refers to whether the data on the tape are ASCII or EBCDIC. The default for this field is ASCII. In this version of AERMET, EBCDIC is not functional; therefore, processing data on an IBM mainframe is not an option.

E.2 UPPERAIR PATHWAY

The syntax for the DATA keyword statement for the UPPERAIR pathway is the same as shown above for the SURFACE pathway. The discussion for the *archive_filename* on the SURFACE pathway applies here as well.

The only upper air data format that AERMET currently processes, whether the data are on diskette or magnetic tape, is the TD-6201 data series. For data on magnetic tape, the data are usually ordered from NCDC as **v**ariable-length **b**locks. To process NWS twice-daily soundings in this format, the *file_format* is specified as 6201VB. Each logical record in the variable-length format contains the upper air observations from one station. Like the TD-3280 format, the user can request that the upper air data be supplied in the fixed-length format, in which case the file format is specified as 6201FB, just as for data on diskette.

For the upper air data, the *factor* defines the number of logical records (soundings) per physical record. As with the SURFACE pathway, this value specifies the number of logical records to process before reading from the tape again. The specification of this factor depends, in part, on the data request submitted to the NCDC.

As for the SURFACE pathway, the *type* refers to whether the data on the tape are ASCII or EBCDIC. The default for this field is ASCII. In this version of AERMET, EBCDIC is not functional; therefore, processing data on an IBM mainframe is not an option.

E.3 DATA ON DISKETTE AND TAPE

There may be occasions when the surface and site-specific data are on a personal computer, but the upper air data are on magnetic tape on a mainframe. There are three options to unite these three data types.

One option is to upload the AERMET source code to the second computing platform to process the upper air data. However, there is some PC-specific code (as noted in Section 6) that would require modification. The code has to do with the system data and time and opening files. The user should consult the appropriate user's manual on what changes or additions to make for the specific computing platform. Once the AERMET system is operational, the upper air data can be processed from tape and then downloaded to the user's personal computer where the remaining processing can be performed.

A second option involves the same operation as above - uploading the AERMET source code - as well as uploading the surface and site-specific data and processing all the data on the second computing platform.

The third option is the reverse of the first two options - download the upper air data to the personal computer. The first step is to copy the data from the magnetic tape to a file on the second computing platform's mass storage <u>without changing the structure of the data</u>. This file of data can then be downloaded to the user's personal computer. However, the size of the file may be a limitation. The user should first determine how much space is required on a personal computer to store the file before downloading it. Some judicious and very careful editing to remove unnecessary records may be necessary on the second computing platform before downloading. Once on the user's personal computer, the file can be processed just as if the data resided on magnetic tape because the <u>structure</u> of the data has not changed. If the user keeps in mind that the structure is the same whether it is "strung out" on a tape or on a disk file, then there should be no problem processing as if it is on tape. If the user did something to change the structure during the copy process, editing process (if that became necessary) or download process, AERMET may not be able to extract any data.

There is not be a preferred option, and there may be other viable options that have not been explored. The user should choose whichever option is easiest to implement.

APPENDIX F

AERMET ENHANCEMENTS

In this appendix, possible enhancements to the AERMET meteorological preprocessor are discussed. These enhancements include the use of the afternoon sounding to adjust the daytime mixing height estimates, an objective scheme to estimate the Bowen ratio, incorporating the effects of anthropogenic heat flux, and estimates of the urban mixing height.

F.1 DAYTIME MIXING HEIGHT ADJUSTMENTS

The mixing height computation currently in AERMET uses the morning (12Z) sounding and the accumulated sensible heat flux to determine the growth of the convective boundary layer. However, changes in the atmospheric sounding during the daytime hours are not accounted for by this scheme. Half of all of the routine soundings now taken are ignored (i.e., the 00Z soundings). Mixing height predictions in the afternoon would be improved by using the 00Z soundings (in the United States) to adjust the computation of this height based upon the morning sounding.

To implement such an enhancement, it is necessary to devise an objective algorithm to find the height of an elevated inversion in the 00Z sounding. This algorithm should ignore any shallow surface-based inversion that could have recently formed if the sounding is taken near or after the hour of sunset. A search is performed for a height interval over which the potential temperature gradient exceeds a user-specified gradient. The height interval examined should probably span at least three sounding points so that a bad data point does not lead to a false detection of the elevated inversion. A preliminary suggestion for the height interval is 200 meters. The potential temperature gradient that corresponds to an elevated inversion would be expected to be at least as stable as isothermal.

Given that an estimate of the afternoon mixed layer height is available, AERMET would then adjust the estimates obtained from the morning sounding and hourly sensible heat flux estimates. If no determination of the afternoon mixing height from the 00Z sounding can be made, then no adjustment would be made to the calculated values currently provided. Otherwise, the afternoon maximum mixing height (at a time estimated to be at a point 75% of the way between sunrise and sunset) would be assigned to the value obtained from the 00Z sounding, and this value would be persisted until sunset. The adjustment of the mixing heights before the time of the afternoon maximum would then be done linearly, with a zero adjustment at the time of the first upward sensible heat flux in the morning, up to the required adjustment at the time of the afternoon maximum to be consistent with the 00Z sounding. The adjustment would be limited to a factor of two.

F.2 AN OBJECTIVE DETERMINATION OF THE BOWEN RATIO

In this version of AERMET, the user specifies a monthly daytime Bowen ratio, chosen from one of three possible values representing the wet and dry extremes, or a typically normal moisture value. These values are a function of the type of surface cover in the particular sector for that month (see Section 5 for a discussion of wind direction sectors). The "dry" Bowen ratio value represents a moisture deficit condition in which the vegetation is under stress. The "normal" Bowen ratio reflects a condition of average rainfall, with sufficient moisture supplied to the vegetative cover to support normal transpiration rates. The "wet" Bowen ratio condition is one of excessive moisture, leading to extra evaporation from surface wetness in addition to the normal transpiration rates. An assumption is made that in the long run, the loss of water to the atmosphere by evaporation is roughly equal to the precipitation gained, and that the appropriate vegetative cover to maintain this steady state is established. The values for the Bowen ratio are chosen for each month as a function of the type of vegetation and its maturity (e.g., leaves emerging in spring, full maturity in summer, or leaves dropping in autumn).

The specification of just one monthly value for the Bowen ratio results in poor temporal variation. The moisture availability can fluctuate significantly within the month. The revised algorithm described here assumes that AERMET is provided with the three moisture-dependent Bowen ratio values for each month, reflecting extremes from wet to dry. The revised method would select one of the values for each day as being the most appropriate.

This new method for AERMET is based in concept on estimates of the daytime sensible heat flux from standard meteorological measurements made by Holtslag et al. (1980). These authors used a modified Priestly-Taylor (1972) model of the energy budget in which the moisture availability (or the daytime Bowen ratio) was empirically found to be a function of the rainfall in the previous 5 days at Cabauw in the Netherlands. This area features a grass cover of approximately 8 cm in length. In the case of little or no rainfall, evaporation rates were substantially reduced, with a correspondingly high Bowen ratio. During periods of normal rainfall, evaporation rates typical of normal transpiration condition were found.

For AERMET, a decision concerning the choice of a wet, dry, or normal Bowen ratio value is analogous to the choice of a moisture availability value by Holtslag et al. The decision for each day would be based upon the previous five days' precipitation total as compared to an average rainfall for the same five-day period. This average rainfall could be the 30-year average or other appropriate period. Similar to the METPRO (Paine, 1987) technique, a five-day rainfall amount that is at least twice the average will result in a "wet" designation. Rainfall less than half the average will result in a "dry" designation. Amounts of rainfall in between these extremes will earn a "normal" designation. For each day, a new running five-day total precipitation total and average would be computed. The Bowen ratio determined with this method will thus be subject to daily fluctuations. However, the Bowen ratio would be the same value for the entire daytime period for any given day.

The required input data to AERMET would consist of hourly precipitation data (as provided on the Solar and Meteorological Surface Observation Network (SAMSON) data, monthly average precipitation, and the three monthly Bowen ratio values (dry, normal, wet).

F.3 URBAN EFFECTS

AERMET uses an energy balance formulation to determine 1) whether stable or unstable conditions are present, and 2) to quantitatively determine for unstable conditions the surface heat flux and other boundary layer values. A simple formula, appropriate for rural areas, is

$$R_n = Q_h + Q_e + Q_g,$$

where

R_n is the net radiation,

Q_h is the sensible heat flux,

Q_e is the latent heat flux, and

Q_g is the soil heat flux.

To date, Q_g has been parameterized in AERMET as 0.1 R_n (after Holtslag and van Ulden, 1983) and Q_h and Q_e are determined from an estimate of the daytime Bowen Ratio (= Q_h/Q_e). The sign of the net radiation is used to determine the sign of the Monin-Obukhov length. This choice is important in AERMOD due to the selection of dispersion algorithms.

A more general expression for the energy balance accounts for anthropogenic heat flux (Q_a) as well as allowing G to be a variable fraction (c_g) of R_n:

$$R_n + Q_a = Q_h + Q_e + c_g R_n,$$

The flux of heat into the ground during the daytime will be parameterized as a fraction (range: 0 to 1.0) of the net radiation. Holtslag and van Ulden (1983) obtained a value of c_g of 0.1 for a grass covered surface in the Netherlands. Oke (1982) indicates that typical ranges for c_g are 0.05 to 0.25 in rural areas, 0.20 to 0.25 in suburban areas, and 0.25 to 0.30 in urban regions.

The anthropogenic heat flux can be neglected except in highly urbanized locations. Table F-1, taken from Oke (1978), provides estimates for urban areas.

TABLE F-1

AVERAGE ANTHROPOGENIC HEAT FLUX (Q_a) AND NET RADIATION (R_n)
FOR SEVERAL URBAN AREAS (FROM OKE, 1978)

Urban area/ latitude/period	Population ($x\ 10^6$)	Population density (persons/km^2)	Per capita energy usage ($MJx10^3/yr$)	Q_a (W/m^2)	R_n (W/m^2)
Manhattan (40°N)					
annual	1.7	28,810	128	117	93
summer				40	
winter				198	
Montreal (45°N)					
annual	1.1	14,102	221	99	52
summer				57	92
winter				153	13
Budapest (47°N)					
annual	1.3	11,500	118	43	46
summer				32	100
winter				51	-8
Sheffield (53°N)					
annual	0.5	10,420	58	19	56
West Berlin (52°N)					
annual	2.3	9,830	67	21	57
Vancouver (49°N)					
annual	0.6	5,360	112	19	57
summer				15	107
winter				23	6
Hong Kong (22°N)					
annual	3.9	3,730	34	4	~110
Singapore (1°N)					
annual	2.1	3,700	25	3	~110
Los Angeles (34°N)					
annual	7.0	2,000	331	21	108
Fairbanks (64°N)					
annual	0.03	810	740	19	18

In addition to the anthropogenic heat flux, an accurate specification of the surface roughness length appropriate for cities would have the effect of increasing the Monin-Obukhov length to account for the near surface shear effects due to building obstacles. Representative values for various urban environments are shown in Table F-2.

TABLE F-2

SURFACE ROUGHNESS LENGTH FOR URBAN ENVIRONMENTS
(from Stull, 1988)

Environment	Roughness length (meters)
Many trees and hedges, few buildings	0.2 - 0.5
Outskirts of towns	0.4
Center of small towns	0.6
Center of large towns and small cities	0.7 - 1.0
Center of large cities with tall buildings	1.0 - 3.0

F.4 URBAN MIXING HEIGHTS

For urban areas, the additional heating due to anthropogenic sources creates a higher convective mixed layer during the day. This effect will be accommodated in a future version of AERMET by a higher sensible heat flux input to the modified Carson model. At night (when a negative net radiation is measured or parameterized), a well-mixed layer is observed near the surface over the built-up areas of cities of all sizes. This layer is caused by reduced upward radiation due to the presence of buildings, as well as the anthropogenic heat flux. The depth of the layer is observed to be on the order of 50-100 meters for small cities, 150-200 meters for moderately large cities, and 300-400 meters over large cities. These observations are consistent with a model proposed by Summers (1965):

$$h_{urban} = \{ 2 H_a x / [c_p \rho (d\theta/dz)] \}^{1/2}$$

where H_a is the anthropogenic heat flux,
x is the upwind fetch length over the urban area, and
$d\theta/dz$ is the vertical potential temperature gradient at the top of the mixed layer.

In a future version of AERMET, H_a and x would be specified by the user as a function of month and (in the case of x) by direction sector. The value of $d\theta/dz$ would be derived from the rural stable θ_* value using boundary layer parameterizations.

TECHNICAL REPORT DATA

(Please read Instructions on reverse before completing)

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16. ABSTRACT AERMET provides a general purpose meteorological preprocessor for organizing available meteorological data into a format suitable for use by the AERMOD air quality dispersion model. This user's guide provides instructions for setting up and running the AERMET preprocessor. National Weather Service (NWS) hourly surface observations, NWS twice-daily upper air soundings and data from an site-specific meteorological measurement program can be processed in AERMET. There are three stages to processing the data. The first stage extracts meteorological data from archive data files and processes the data through various quality assessment checks. The second stage merges all data available for 24-hour periods (NWS and site-specific data) and stores these data together in a single file. The third stage reads the merged meteorological data and estimates the necessary boundary layer parameters for use by AERMOD. Two files are written for AERMOD: a file of hourly boundary layer parameter estimates and a file of multiple-level observations of wind speed and direction, temperature, and standard deviation of the fluctuating components of the wind. AERMET was designed to allow for future enhancements to process other types of data and to compute boundary layer parameters with different algorithms.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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